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Why NOT a Higher Price for Crude Oil?

Oil Progress Week recently was observed throughout the country. The American petroleum industry for the fifth year sought to acquaint the general public with the accomplishments that this industry has made, operating under a free enterprise system. By and large these accomplishments are well known to those engaged in petroleum activities, but it may be well to review some of the immediate ones and to ask whether this progress can continue in like proportions under certain existing conditions of restriction.

The year of 1952 is well on its way to establishing records in respect to crude oil production, new producing wells drilled, refinery output, and pipe line and refinery construction. More specifically, it is now predicted that the year will end with 46,000 new wells drilled, although handicapped by the steel strike, a figure that it is hoped will be increased to 55,000 next year and 60,000 in 1954. Pipe lines have continued their spectacular expansion. During the 15-month period ending September 1, a total of 16,591 miles of crude oil and products pipe lines was authorized by the Petroleum Administration for Defense. Natural gas pipe lines, under jurisdiction of the Federal Power Commission, showed a proportionate expansion. Refining capacity has been increasing at the rate of approximately 50,000 barrels a day. These are accomplishments to be proud of, but it is important that these expansions continue. It is important because to maintain the present level of petroleum reserves, it is necessary to find more than one barrel of oil for every barrel used. Each year now 2½ billion barrels of oil products are being consumed and demand has been increasing at the rate of 5 per cent per year.

In view of such demands, what is the position of the industry to produce these amounts? When World War II began the industry was capable of producing 30 to 40 per cent more oil than the then existing demand. Because of the great demands made upon it by the Korean War, the West Coast today is a net importer, whereas the area east of the Rocky Mountains has the ability to produce only 10 to 15 per cent more oil than the current demand. This cushion of reserves would be sadly inadequate should another major war occur. To assure that these reserves are found, first of all among the requisites is materials. Fortunately, the supply of materials is improving, although by no means adequate for all demands. After materials must come the incentive to use them. Thus we arrive at the subject of higher crude oil prices, to encourage exploratory activity, as well as improve techniques that will make possible the recovery of a greater percentage of the 100 billion barrels of reserves in existing fields.

Today's average price for crude oil is $2.57 a barrel, exactly what it was five years ago, pegged some 25 per cent below the level of all other commodities. Consistent and strenuous efforts by numerous industry organizations as yet have been to no avail. The Independent Petroleum Association of America has warned the Office of Price Stabilization that secondary wells are being abandoned as unprofitable to produce, and drilling may decline without price adjustment. The cost of drilling oil wells admittedly has increased sharply since the start of the Korean War, largely due to higher steel costs and wage advances.

Furthermore, virtually every other major industry has been granted a price ceiling increase.

Why *not* a higher price for crude oil?—F.H.L.

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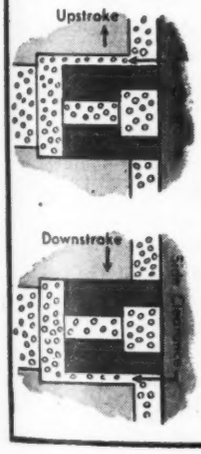

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With the EDITORS.....

The Petrochemicals Race

The petrochemical industry is not giving its member companies, or the public, a chance to look back and see how far it has advanced. The rate of growth, the breadth and complexity of the developments during the last 2-3 years is beyond the stretch of ordinary imagination, making even the growth of the "parent" petroleum industry seem staid and ox-wagon-like by comparison.

Now comes the Federal Trade Commission, perplexed as to what to do. Shall that body, moving with typical Government bureau speed(?), begin a statistical survey of this mushrooming industry to bring us up to date on its current status and composition, or would the results of such a report be of any immediate value? Given at least a year to make up and release a report, the industry in the meantime would pass completely out of hearing, to judge by its immediate past history and its current indications. Reminds us more or less of the backwoods farmer who complained to the fertilizer salesman about the fact that no pumpkins were grown on his vines. "Yeh, I planted them seed with a pound of yore fertilizer in each hill, jist as ya told me to. But, ye know, them vines growed so fast they drug off all the young punkins, and not ary a one growed up!"

The FTC would find, probably, that at the end of a year the new capacity for petrochemicals has increased the total output of the industry by 10 per cent or more above that operating at the beginning of the survey period. If the industry itself cannot keep its progress reports up to date there is little chance for any Federal or other agency to accomplish that job satisfactorily. Only dependable record form for the petrochemical industry is a loose-leaf notebook.—A. L. F.

The Need Is Urgent for Small Pipe

In the construction of oil pipe lines, the trend in recent years has been progressively to the use of large-diameter pipe. When the War Emergency Line was laid of 24-in. pipe in 1942 it was termed the "Big Inch" because it was far and away the largest diameter crude oil line built to that time. Since then, however, numerous lines of equal or greater diameter have been constructed. It is not too surprising, in view of all the facts, that minimum thought should be given to small diameter pipe. There is, however, a critical need by crude oil and products pipe lines for small pipe. The situation is revealed in a report to J. Ed Warren, deputy administrator of the Petroleum Administration for Defense, by the Committee for Pipe Line Companies, of which J. L. Burke, president of the Service Pipe Company, is chairman.

Data obtained from 41 pipe line companies, which operate 39,500 miles of crude oil lines and 16,000 miles of products lines, establish several significant facts: (1) That an average of 1660 ft of 10-in. diam pipe and under, weighing 14.16 tons, is needed to connect each new oil well to a pipe line outlet; (2) the supply of salvable pipe in the ground is diminishing; less than half as much is available for take-up in 1952 as in 1951, and this percentage will decline further in 1953 and thereafter; (3) there is a serious shortage of thin-wall pipe.

Being more specific, the committee's report estimates requirements for the next several years for 2-in. through 10-in. new and secondhand pipe to be as follows, in tons:

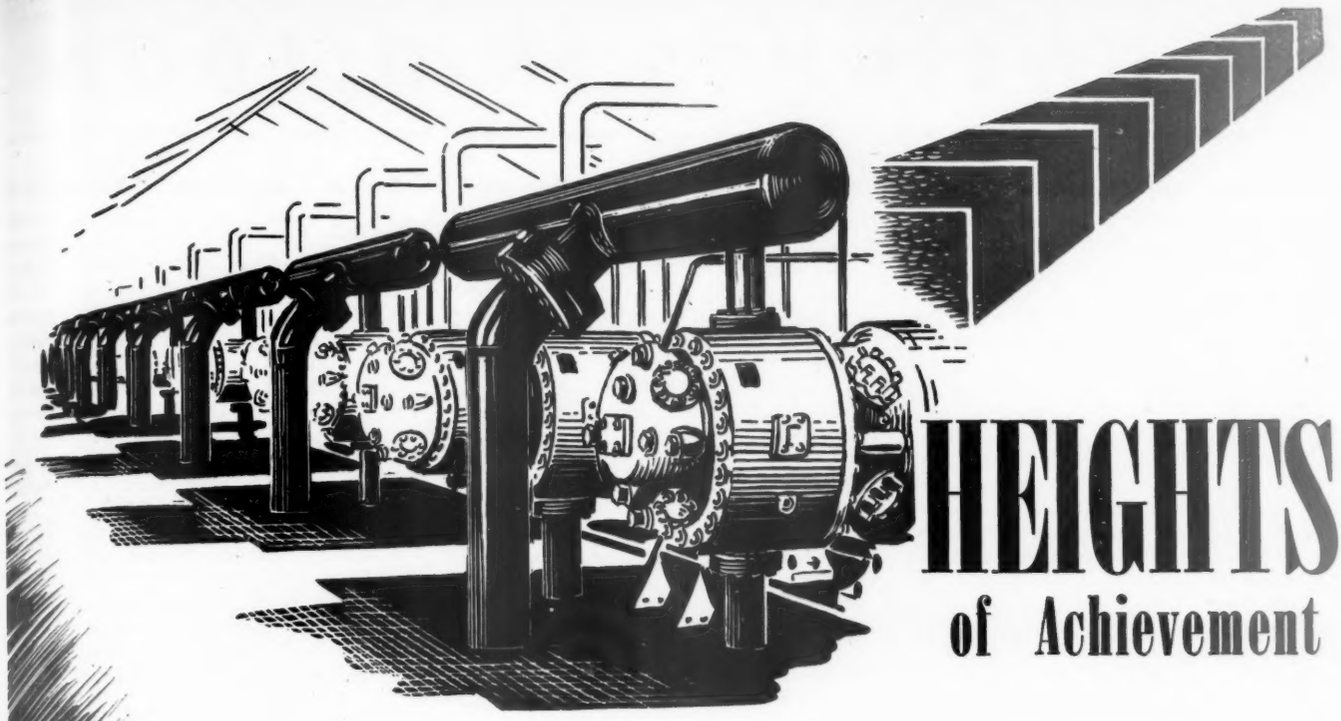
Size, in.	1952	1953	1954	1955
2	7,678	8,523	9,298	10,040
3	12,486	13,830	15,083	16,285
4	73,776	81,265	88,734	95,891
6	77,530	81,905	88,630	95,074
8	123,900	128,726	135,651	142,288
10	124,569	133,796	144,624	155,000
Totals	419,939	448,045	482,020	514,578

It all adds up to the need for manufacturing more small diameter pipe than in the past. In a letter transmitting the report to Deputy Administrator Warren, Burke said: "The result (of this study) is that a substantially increased percentage of the industry's needs must be met by new pipe; over 50 per cent more 3 and 4-in., and almost four times as much 6-in. must be made available as new pipe in 1952 as was available in 1951, and the need for new pipe will increase in 1953 and thereafter as available take-up and salvage declines."

The conclusion reached is that the large tonnage of steel already committed to drilling and refinery expansion programs will be wasted unless matched with sufficient footage of small pipe for the pipe line transportation link. Without this pipe new wells cannot be connected and refined products cannot be moved to destination, and that is why the reporting pipe line companies have expressed concern over the possibility of these requirements being underestimated.—F.H.L.

Dearth of Chemists

Among the numerous insistent notes sounded during the mid-September meeting of 8000 members of the American Chemical Society in Atlantic City was that which sounded mightily like "Our Kingdom for more chemists!" This shortage appears to be quite general and bids fair to become worse before it is better. Some of the blame for it is laid to reduction in chemical student enrollment before World War II; lack of perspicacity on the part of the military authorities in withdrawing chemical students from school for service duty, during and after that war, including the famous (?) "police action in Korea"; and not least is the formerly serious inadequate financial returns to the chemist in industry, as compared to the time and money expense required for his proper education, a matter now being corrected in a measure by increased salaries for technical men in general. Only 5000 chemists will be graduated from colleges in 1955, compared to more than 10,000 in 1950. In all industry chemists and engineers are in greater demand than ever before. In a normal "supply and demand" economy this situation, while discomforting and problematic for a time, will correct itself, increased financial returns induced by the chemist shortage attracting more and better students to the field to relieve the shortage.—A.L.F.



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HIGHLIGHTS IN OILDOM

California Oil Shortage

A serious shortage of oil exists in California, Standard Oil of California has reported. This is the state that is second only to Texas as a crude oil producer. Production in California is running at nearly 1,000,000 bbl, but that's an estimated 50,000 bbl short of the demand. "We'd rather find a barrel of oil in California today than anywhere else in the world," says Sam F. Bowlby, West Coast vice president of Shell Oil Company. To alleviate the shortage a Texas group, West Coast Pipeline Company, has been granted PAD approval for steel to build a 960-mile pipe line from Wink in West Texas to Norwalk, California. Another pipe line project from Texas is being planned by Progress Pacific Pipe Line Company.

Atomic Energy Source Seen

When the coal and oil of the U. S. are all used up, the nation will have a new energy source, Charles F. Kettering, vice president of General Motors Corporation, told Texas oil men in Fort Worth recently. Addressing the opening day session of the Texas Mid-Continent Oil and Gas Association, the famed inventor-engineer, expressed the belief that scientists will eventually be able to harness the sun's energy, and declared, "One acre of ground ought to be enough to run an automobile for a year." Kettering added that he was speaking in "long-range" terms, and could foresee no immediate competition between scientists and oil men.

Right Basin — Wrong Bureau

President Truman gave oil men in North Dakota what was perhaps their best laugh in months. On a speaking tour through the Dakotas and Montana, he persistently declared that the government had played a big part in the discovery of oil in the Williston Basin, claiming the U. S. Coast and Geodetic Survey mapped the area some time ago. Actually, it was the U. S. Geological Survey which did the mapping. Some of the President's advisors were told that the U. S. Coast Geodetic Survey is a branch of the Commerce Department, and that the U. S. Geological Survey is affiliated with the Interior Department.

First Oil Well Driller Honored

The grave of William A. (Uncle Billy) Smith, the nation's first successful oil well driller, has been honored with a 20-ft memorial shaft. The shaft was placed on his grave during Oil Progress Week as a "fitting tribute to the memory of the all-but-forgotten driller of the first well, the Drake well." Smith was hired by Drake to drill a well for oil near Titusville, Pennsylvania. After making the first drilling tools by hand, he brought in the first well on August 27, 1859 at a depth of 69½ ft.

Federal Controls Attempts Hit

The oil industry has been alerted against federal attempts to control petroleum activities. Russell B. Brown, general counsel of the Independent Petroleum Association of America, told industry members that one such attempt was the attack on leading oil companies for their alleged participation in an international oil cartel thus branding them as a monopoly.

Previously Frank M. Porter, API president, had warned attendants at an Oil Progress Week dinner against governmental efforts to curb activities of the oil business. He added that progress of all industry including oil "can only be defeated by the deadening influence of governmental bureaucracy."

Williston Basin Influence

The Williston Basin of Montana and the Dakotas will exert a strong influence on the "refining, transportation, and marketing patterns in the Midwest," Dwight F. Benton, Standard Oil Indiana, predicted in an Oil Progress Week talk in El Dorado, Arkansas. Benton said that crude oil from this new area might cut the amount of oil brought into the Midwest from the South and Southwest, traditionally the main suppliers. Development of the Basin will be expensive and slow, Benton cautioned.

Autos Cost Oil Firms $765

When you buy that new car the oil industry has to put up $765 for every additional automobile that goes on the road. That's what it takes to buy the producing, refining, and distributing equipment needed to keep the car rolling with gasoline and lubricants, according to J. W. Moss, Standard Oil Company executive, of Chicago. Ross was explaining the "enormity of the oil industry's capital needs, based simply on the illustration of one additional car on the road," to an Oil Progress Week luncheon meeting of the St. Paul, Minnesota, Kiwanis Club. Oil companies, Ross said, are spending this year more than $2,000,000 a month in the Williston Basin. One of the things that makes such outlays possible is the percentage depletion deduction, he said, calling the tax provision "a good thing for our country." "Without it," he asked, "who would take the risks . . ."

Crude Output Shows Gains

Texas and Kansas' crude oil production this year may surpass that of 1951. In Texas the Texas Mid-Continent Oil and Gas Association using September allowables as a measure calculate fourth quarter production will be approximately 1,037,000,000 bbl. That would compare with 1951's record flow of 1,010,000,000 bbl.

Kansas produced 342,935 bbl daily in September, making total output 10,288,050 bbl, third record this year.

Can U. S. Develop Oil Resources?

In a speech at the Kilgore, Texas, Jub-OIL-lee, Miss Ernestine Adams, managing editor of *The Petroleum Engineer*, examined past experience of state and of federal control of oil operations. She concluded: "The United States would be better served with state-controlled marginal seas. It doesn't matter whether you live in Texas or Tennessee, the record shows that you will have 'oil for all the people' and oil for national emergency in greater abundance and at less cost if submerged lands are controlled by local governments rather than by federal bureaus. If past performance means anything at all, the U. S. will collect more taxes from oil development in state-owned marginal seas than it will collect directly from leases and royalties of federal-controlled tidelands."

Foreign Oil Cooperation Urged

Foreign oil is becoming increasingly important to the free world and "another look should be taken at the problems of foreign oil and possible ways and means of reconciling and protecting the interests of the U. S., other oil-producing and consuming countries of the free world, and of the operating companies." That is the belief of Walter J. Levy, consulting engineer, speaking at the Petroleum Branch of the American Mining and Metallurgical Engineers meeting in Houston, Texas, recently. Levy pointed out that the same objections and fears previously raised in connection with an international oil agreement were also voiced at the time when the Interstate Oil Compact was first established in the U. S.

City Sinking Two Feet a Year

Geologists believe that withdrawal of fluids and gases is responsible for the fact that Long Beach, California, is sinking into the sea at the rate of about 2 ft per year. They expect it to keep sinking until 1965 when the center of the saucer-shaped depression in the earth's crust will be down about 23 ft. Perhaps costliest damage done to the city by the depression happened recently when earth layers above the 1700-ft level slipped inward toward the center of the depression, aided in part by earthquake jars. Displacement was about 13 in., enough to pinch off the casings of more than 200 oil wells.

Local Markets Advised

"Oil from Williston Basin, one of the largest sedimentary basins in continental North America, should find its market locally rather than by competing in distant markets, as the estimated growth in Williston production capacity will approximate the increase in local demand." This conclusion was reached by John G. Winger, petroleum analyst of the Chase National Bank, at the fall meeting in Houston, of the Petroleum Branch of the AIME.

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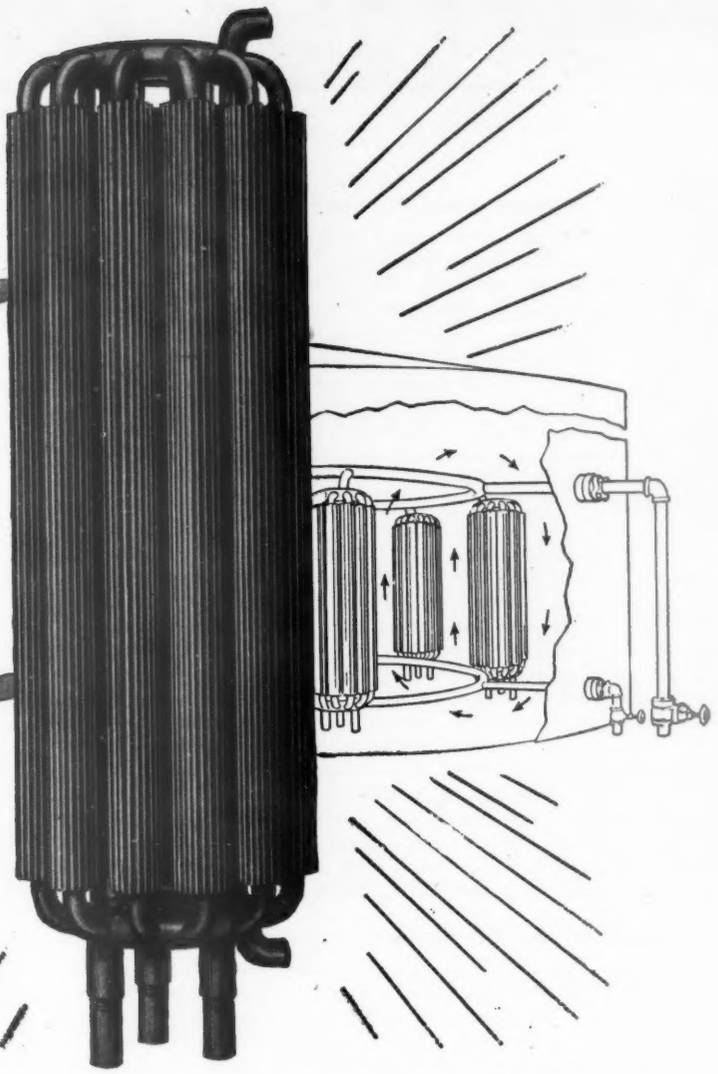

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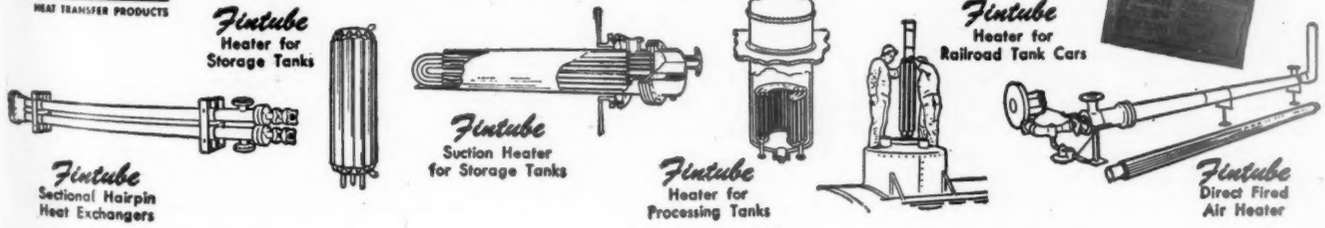

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PETROLIC PERSONALITIES

DICK SNEDDON

New Yorkers Migrate to California

Out of the eastern azure on a recent Friday afternoon, there zoomed into the Palm Springs area of California a DC3, bearing a rare assortment of sky men. The delegation consisted of nine consequential New Yorkers who had come to the Thunderbird Ranch, whence Hal "Aromatic" Davis, the Big Shot of the Nineteeners had summoned all his henchmen, to quaff the flowing cup and to thrash the greensward mightily with their niblicks. This latter is a religious rite of the Nineteeners which they call a Calcutta and it is supposed to bring a bountiful harvest to those who are most lusty with their flails. When the ship grounded, the passengers stepped down to *terra firma,* immaculately clad in tall hats, winged collars, bow ties, black patent shoes, spats, and abbreviated tartan shorts. It was as pretty a display of male gams as Palm Springs had seen in many a day and the vestments were most becoming garnishment.

Leading the parade was that well known Danbury boy, Joe Taylor, now general purchasing agent for Socony-Vacuum Oil Company, who scorned the old idea of starting at the bottom and began his working career as a hatter. Joe is an honorary member of the Nineteeners and is almost as well known and highly respected in Los Angeles as he is at the Downtown Athletic Club of New York of which he is a past president. Accompanying Joe was his durable aide, Bill Beck, assistant general purchasing agent of Socony, who in 1920 went to Los Angeles on his honeymoon and stayed 26 years. Bill is a past Big Shot of the Nineteeners, a former governor of the Downtown Athletic Club aforementioned, and is probably the most feared gin rummy player on the American continent.

Of Golfers and Gardeners

These disciples of Pegasus and the other members of the Big City contingent were traveling guests of two grand people from the Johns-Manville Company, to wit, Jack Aloysius O'Brien and Les Baldwin, both vice presidents and as unassuming and thoroughly friendly as they come. Jack is a native New Yorker and has been with J-M for a trifling 37 years. He plays his golf in the Winged Foot Club sand traps at Mamaroneck, New Jersey, and despite his Hibernian descent, looks right sharp in Caledonian shorts and a Pickadilly swallowtail. Les Baldwin is a quiet mannered but interesting chap whose hobbies are golf and growing tuberous begonias. He won the visitor's prize at Thunderbird for his prowess.

One of their flying companions was that old Notre Dame alumnus, Henry McAdams, who functions with distinction as New York manager for Jones and Laughlin. Henry is a former basketball and baseball star and altogether has more energy than a can of TNT. He is an ex-prexy of New York Nomads, past governor of the Downtown Athletic Club, and plays his golf at Bonnie Brier.

Also in the cavalcade was Elmer Ogden, manager of Columbia Rope Company, and one of the few persons we know whose golf score does not constitute a nasty smear on the family escutcheon. Elmer lives in Plainsville, has twice played in the national amateur, and keeps himself in training at the Baltusrol Golf Club in Short Hills. Frank Shlemmer, that good-looking purchasing chap, formerly with The Texas Company, now eastern representative of Pacific Valve Company, tagged along, too, and looked very dapper as he stepped out of the plane in his vaudevalle regalia. Frank was born in Brainard, Minnesota, but migrated to California as soon as he was old enough to read the Chamber of Commerce folders. He is not very old even now but has had a lot of experience in purchasing and what he can do with a driver to the area immediately surrounding a golf ball is amazing—even to Frank.

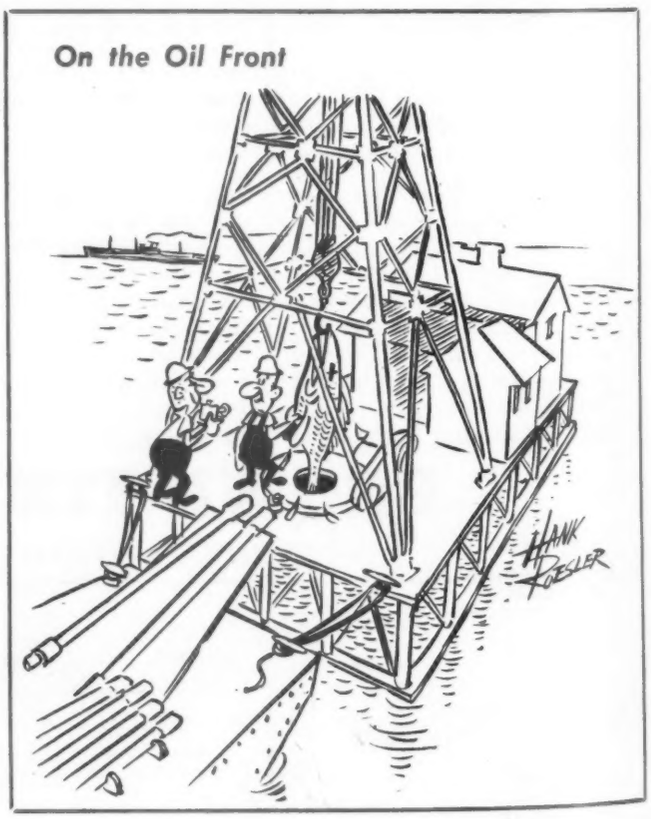
Making his first trip to California and, if his boyish grin meant anything, enjoying it immensely was Jack Rolland, a sort of contracting genius who back in New Amsterdam is known as the "Jock McLeod of the eastern seaboard." Then there was Bill Behrens, a noted New York broker who, in his own bailiwick chums around with Sherman Billingsley over at the Stork Club, promotes the sale of "Sortilege," and is considered something of a ruffian in a gin rummy bout. Somewhere along the way this constellation of intellects was joined by Joe Hacker, vice president of the Ladish Company in Cudahy, Wisconsin, who is an alumnus of Marquette, member of the Blue Mound Golf Club in Milwaukee, proprietor of a hunting estate in Wild Rose and one of the craftiest fly fishermen since Izaak Walton.

Houstonians Join the Fracas

From deep in the heart of Texas came another skybird, bringing three more notables. One was Paul Huggins, the Gulf Oil Corporation veep from Houston. Being originally from the Lone Star state, Paul is already quite at home back in Houston. Another passenger was the ubiquitous and irrepressible Al "Dutch" Zwerneman, who deserted the blue Pacific some time ago and now operates his own organization, Atlas Pipe and Supply Company, in Houston. Here's a lad with a lot of business savvy and the energy to make the best of it.

Last of the Houstonians was that entertaining chap, Ed Fisher, district manager of the Mid-Continent and Gulf areas for Pacific Wire Rope, and one of the roughest pitch players west of the Mississippi. Although born in Old Albion, Ed is as western as Roy Rogers. Streaking in from San Francisco came Claude Lane to humiliate the Southern boys no end by picking up half the Calcutta money. Claude is a fabulous hunter and looks practically naked with no ducks over his shoulder. He was accompanied by Dick Townley, C. F. Braun representative, known as Seabiscuit because of his uncanny ability to win under any handicap.

Hal Detrick, the A. O. Smith veep from Milwaukee, also flew in for the doings. Deet is a master of the badinage that goes with gin rummy and golf. Last of the out-of-town members was Carlos Rudolfo Schneider from Mexico City. This lad's favorite pastimes are going the wrong way in square dances and staying up all night. With 42 regular members to augment the gathering, it was an unforgettable affair, to which we herewith subscribe our hand and seal.



The Petroleum Engineer

November 1952

H. S. M. Burns
Shell Oil Company

L. S. Wescoat
Pure Oil Company

Howard G. Vesper
California Research Corporation

Robert E. Wilson
Standard (Ind.)

Theodore S. Petersen
Standard of California

API

Giant organization draws members of the industry from all corners of the nation to 32nd annual meeting

AMERICAN Petroleum Institute is holding its 32nd annual meeting in the Conrad Hilton Hotel and Palmer House, Chicago, Illinois, November 10 to 13.

A group session on fundamental research will open the meeting in the Conrad Hilton Hotel, November 10. The session will begin at 9:30 a. m. and Howard G. Vesper, California Research Corporation, chairman, Advisory Committee, will preside. Robert E. Wilson, chairman of the board, Standard (Indiana), will make the opening remarks and present the API "Certificate of Appreciation." Other speakers are members of the Research Project Advisory Committee: S. S. Shaffer, Humble; Harry Sutherland, Shell Oil; W. E. Kuhn, The Texas Company; W. G. Lovell, Ethyl Corporation; W. D. Seyfried, Humble, and R. R. Brattain, Shell Development.

H. S. M. Burns, president of Shell Oil, and chairman, Public Relations Committee of the Board of Directors, will address a group session on public relations, at 10 a. m., Monday, November 10.

A symposium on "Evaporation Loss" will be held at 2 p. m. Monday, in the Conrad Hilton South Ballroom. J. H. McClintock, Esso Standard Oil Company, will preside. Three group papers will be presented discussing the basic theory and mechanism. The first is "A Review of the Basic Theory and Mechanism—and an Outline of the Practical Problems," presented by C. C. Ashley, consultant, and discussed by O. W. Johnson, Standard California. "Losses from Cone-Roof Tanks" is the second paper, presented by I. L. Wissmiller, Chicago Bridge and Iron, and discussed by S. S. Smith, Shell. H. L. O'Brien, Graver Tank and Manufacturing, will present the paper "Evaporation from Conservation-Type Tanks—A Practical Review," and A. B. Stevens, General Petroleum, will discuss it.

The next general group session will convene at 2 p. m. November 11, in the North Ballroom of the Conrad Hilton. Cyrus S. Gentry, chairman, American Petroleum Industries Committee, will preside over the open meeting, and H. S. M. Burns, will make the address. The API "Certificate of Appreciation" will be presented by George V. Holton, Socony-Vacuum, chairman of the board, and James J. Cosgrove, Continental Oil, chairman of the board, will make the recipient's response. A color film presentation "Alerted for Action" will close the session.

L. S. Wescoat, president Pure Oil, and chairman, API directors, will preside over the third general session at 9:30 a. m., November 12. A report will be given of the board of councillors and election of directors will be held. Remarks will be made by Frank M. Porter, API president, and L. S. Wescoat, and Oscar L. Chapman, U. S. Secretary of the Interior, will make an address.

Final general session will be held November 13 at 9:30 a. m. L. S. Wescoat will preside, with addresses by T. S. Petersen, Standard California; Oveta Culp Hobby, co-publisher, the *Houston Post;* and William F. Knowland, United States Senator, California.

S. S. Shaffer
Humble

W. G. Lovell
Ethyl Corp.

R. R. Brattain
Shell Development

W. E. Kuhn
The Texas Co.

W. A. Bruce, Carter Oil Company, will speak on "Use of High Speed Computing Machines for Oil Field Purposes."

Glenn M. Stearns, British-American Oil, will preside with W. L. McCoy, Jr., at a production session at 1:30 p.m. Tuesday.

R. C. Zell, Union of California, will speak on "Demand for and Supply of Tubular Goods—Present and Future."

Paul Andrews, Signal Oil and Gas, is chairman of the steering committee on production practice.

D. V. Carter, Magnolia Petroleum, is chairman of the editorial board, Central Committee on Drilling and Production Practice.

Ralph E. Davis, consultant, Houston, Texas, will speak on "Natural Gas in an Expanding Economy."

S. F. Bowlby, Shell Oil, will deliver a paper on "Significance of the Williston Basin."

R. O. Garrett, Arkansas Fuel Oil Company, is chairman of the executive committee on drilling and production practice.

George E. Cannon, Humble, will preside with R. O. Garrett at a production group session at 2:00 p.m. Wednesday.

F. H. Willibrand, Sohio, will speak on "Supervisory Development" at a group session at 2:00 p.m. Wednesday.

Lloyd E. Elkins, Stanolind, will speak on "Production Research and Its Application to the Growing Demand for Petroleum."

W. L. McCoy, Jr., Sohio, is chairman of the division of production's steering committee on drilling practice.

Production

DIVISION of Production will hold its first group session at 1:30 p. m. in the Conrad Hilton Grand Ballroom, with Glenn M. Stearns, British-American Oil, and W. L. McCloy, Jr., Sohio Petroleum, presiding. J. C. Donnell, II, president, Ohio Oil Company, will make the "Certificate of Appreciation" presentation. Other speakers and their subjects will be W. A. Bruce, Carter Oil, "Use of High-Speed Computing Machines for Oil-Field Problems;" Lloyd E. Elkins, Stanolind Oil and Gas, "Importance of Organized Research in Drilling and Production;" R. C. Zell, Union Oil of California, "Demand for and Supply of Tubular Goods—Present and Future," and E. R. Brownscombe and A. B. Dyes, Atlantic Refining, "Water-Imbition Displacement—A Possibility for the Spraberry."

The second group session will be held at 2 p. m. November 12, with R. O. Garrett, Arkansas Fuel Oil, and George E. Cannon, Humble Oil, presiding. "Supervisory Development" will be discussed by Frank H. Willibrand, Sohio Petroleum; "Significance of the Williston Basin," by S. F. Bowlby, Shell; "Natural Gas in an Expanding Economy," by Ralph E. Davis, consultant, and Report of Division's Nominating Committee, given by H. H. Healy, Ohio Oil, after which members of the General Committee of the Division of Production will be elected.

On Sunday, November 9, D. V. Carter will be chairman of a meeting at 2 p.m. of the Editorial Board (of the Central Committee on Drilling and Production Practice) in Conrad Hilton, Room 13. Also at 2 the API-AWS Committee on Tank Welding will meet in the Conrad Hilton—PDR 4, with H. O. Hill as chairman. In the evening, the Publications Committee (of the Central Committee on Drilling and Production Practice) will meet at a dinner with Paul Andrews as chairman.

Committee and subcommittee meetings will begin on November 10, at 9 a. m. Chairmen will be W. L. McCloy, Jr., F. H. Willibrand, B. B. Wescott, H. C. Boardman, J. H. Field, and W. P. Kliment. Afternoon session begins at 2 p. m. with J. G. Norton, Glenn M. Stearns, and W. I. Kent, chairmen. George E. Cannon will be chairman of the dinner meeting at 6:30 p. m., of the program committee (of the Central Committee on Drilling and Production Practice) in the Conrad Hilton—PDR2.

Four committee meetings will be held November 11 at 9 a. m. They are headed by R. O. Garrett, John A. Ritter, H. S. Kelly, and C. C. Ashley. Lyle Payne and Lot Bowen will head the two afternoon meetings at 2 p. m. and H. H. Healy will be chairman of the Nominating Committee, which meets at 4 p. m.

The Central Committee on Standardization of Oil Field Equipment will meet at 9 a. m., November 12, with John R. Suman chairman of the all-day meeting. The General Committee of the Division will meet at 12:30. J. C. Donnell, II, will be chairman.

Refining

DIVISION of Refining group session will meet at 2 p. m. November 10 in the North Ballroom of the Conrad Hilton Hotel. W. L. Stewart, Jr., Union Oil of California, will preside, and W. J. Sweeney, Standard Oil Development, will give the report of the division's nominating committee. Members of the General Committee will be elected, after which members will hear John E. Swearingen and John W. Boatwright, Standard Indiana, discuss "Future Availability of Petroleum and Ability of the Industry to Meet Requirements."

The second group meeting will be the Lubrication Session, which will convene November 12 in the same ballroom. Presiding over the session will be B. G. Symon, Shell Oil, with W. B. Perrigue, Esso Standard, giving the address. Other speakers will be Donald C. O'Hara, National Petroleum Association, "Let the Customer Vote!"; G. A. Round, Socony-Vacuum, who will discuss "New API System of Service Classifications and Designations for Motor Oils," and H. G. Moock, lecturer and sales counselor, who will speak on "Selling is Everybody's Business."

Division of Refining will begin its subcommittee meetings on November 7 at 9 a. m. Chairman of Safety and Relief Valves Committee will be L. P. Stillman. W. L. Bowler will preside over the joint meeting of Subcommittee on Low-Pressure Storage Tanks and Manufacturers Subcommittee on Low-Pressure Storage Tanks at 10 a. m. W. P. Kliment will head the 2 p. m. session of Manufacturers Subcommittee on Refinery Valves. in Conrad Hilton—PDR 3.

Two meetings will be held November 9 at 9 a. m. A. E. Miller will be chairman of the Committee on Petroleum Products, and E. F. Voss will preside over the joint meetings of Subcommittees on Mechanical Equipment and Centrifugal Pumps. In the afternoon, John T. McCoy will be chairman of the Automotive Research Committee at 2 p. m. and at the same time, J. H. Urian will head the subcommittee of refinery inspection supervisors. A committee meeting on valves will be headed by R. H. Bungay.

Four committee and subcommittee meetings will be held November 10 at 9 a. m. E. Q. Camp will be chairman of the Corrosion Committee, H. M. Holaday, Program Committee, N. J. Rees, Unfired Pressure Vessels, L. M. Goldsmith, Electrical Equipment. At 11 a. m. M. Halpern will be chairman of the Advisory Committee and at 4 p. m. W. J. Sweeney will meet with the Nominating Committee.

November 11, is scheduled for the 9 a. m. meeting of the Committee on Refinery Equipment, W. H. Creel, chairman.

W. L. Stewart, Jr., will be chairman of the National Committee on Smoke and Fumes, also at 9 a. m., and General Committee, at 2 p. m. Last meeting is that of the Subcommittee on Electrical Equipment, L. M. Goldsmith, chairman.

Albert B. Stevens, General Petroleum, will present a discussion at the Symposium on Evaporation Loss.

Harry Sutherland, Shell, is chairman of a research project advisory committee and will deliver a paper Monday.

J. E. Swearingen, Standard of Indiana, is co-author of a paper "Future Availability of Petroleum and Ability of the Industry to Meet Requirements."

W. J. Sweeney, Standard Oil Development, is chairman of the refining division nominating committee.

J. W. Boatwright, Standard of Indiana, is co-author of the paper with J. E. Swearingen, to be delivered at 2:00 p.m. Monday at the refining.

W. L. Stewart, Jr., Union Oil of California, is vice president for refining, chairman of refining general committee and committee on smokes and fumes.

A. E. Miller, Sinclair Refining, is chairman of the Technical Oil Mission Study group and committee meeting on petroleum products.

Wayne E. Kuhn, Texas Company, will give a paper at the Fundamental Research session at 9:30 a.m. Monday.

Wilson David Seyfried, Humble, is chairman of the research project on Sulfur Compounds in Petroleum.

John H. McClintock, Esso Standard, will preside at the symposium on Evaporation Loss at 2:00 p.m. Monday.

M. Halpern, Texas Company, is chairman of the advisory committee which will meet at 11:00 a.m. Monday.

George A. Round, Socony-Vacuum, will speak on the new API system of classification for motor oils.

P. C. Spencer, president of Sinclair Oil, will speak on "Good Industry Relations—Inside and Out."

J. R. "Dick" Ellis, Sunray Pipe Line Company, will speak on "A Microwave-Controlled Pump Station."

R. G. Strong, Natural Gas Pipe Line Company of America, will give a paper on pipe line symposium.

George K. Manning, Battelle Memorial Institute, is co-author of a paper with Joseph W. Lodge.

B. Brewster Jennings, president of Socony-Vacuum, will discuss effects of competition on transportation.

J. G. Norton, Magnolia Pipe Line Company, is co-author of "New Pipe Line Field Welding Code."

Joseph W. Lodge, Batelle Memorial Institute, is co-author of "Stress in Large-Diameter Gas-Transmission Pipe."

John W. de Groot, Tuscarora Oil, is chairman of the subcommittee on Products Pipe Line Technology.

H. H. Anderson, Trans Mountain Pipe Line Company, will preside at meeting on Pipe Line Technology.

R. H. Lynch, Keystone Pipe Line Company, will speak on "People, Pipe Lines, and Public Relations."

R. B. McLaughlin, Texas Pipe Line Company, is chairman, Central Committee on Pipe Line Transportation.

S. S. Smith, Shell Oil, will give a paper, "Recent Products Pipe Development."

Transportation

First group session of the Division of Transportation will be held at 2 p. m. in the Red Lacquer Room of the Palmer House. P. C. Spencer, Sinclair Oil, will preside. Speakers include Vice Admiral W. M. Callaghan, Commander, who will speak on "Military Sea Transportation Service;" B. Brewster Jennings, Socony-Vacuum, who will discuss "Effects of Competition on the Development of Transportation," and John S. Burchmore, attorney, who will discuss "Government Regulation of Transportation," Spencer will present the "Certificate of Appreciation," and a report of the Division's Nominating Committee will be given by M. E. Nuttila, Cities Service. Members of the General Committee of the Division of Transportation also will be elected.

R. B. McLaughlin, Texas Pipe Line, will preside over the two groups sessions to be held November 11. First session will be at 10:45 a. m. in the Red Lacquer Room, and will feature three speakers. J. R. Ellis, Sunray Pipe Line, will talk on "A Microwave-Controlled Pump Station;" J. W. Lodge and G. K. Manning, Battelle Memorial Institute, "The Stress in Large-Diameter Gas-Transmission Pipe," and R. G. Strong, Natural Gas Pipe Line of America, and J. G. Norton, Magnolia Pipe Line, will discuss "The New Pipe Line Field Welding Code."

At 2 p. m. the second transportation session of the day will include talks on pipe line public relations, organizations, and products developments. Speakers will be R. H. Lynch, Keystone Pipe Line, H. H. Anderson, Trans Mountain Oil Pipe Line, and S. S. Smith, Shell Oil. S. M. Blair, Trans Mountain Oil Pipe Line, will discuss "Canadian Oil Production and Transportation."

Transportation committee and subcommittee meetings will be held Sunday, Monday, and Tuesday. Sunday morning at 9 a. m. November 9, L. S. Wrightsman will be chairman for the subcommittee for "Joint ASME-API Volunteer Research." J. C. Stirling and John D. Peterson will be chairmen of subcommittee meetings on pipe line construction practices and pipe line hydraulics respectively, at 9:30 a. m. At 10 a. m. D. C. Glass will be chairman of the Subcommittee on External Corrosion. Beginning at 2 in the afternoon, joint meetings of the various subcommittees will be held in the Crystal Room of the Palmer House.

At the same time Sunday afternoon, other committees will hold joint meetings in the Palmer House, and in the evening at 8 o'clock, J. W. deGroot will be chairman of a meeting of the subcommittee on Products Pipe Line Technology.

Subcommittee meetings for the Transportation Division will continue Monday at 9 a. m. until the noon luncheon for transportation speakers, with P. C. Spencer, chairman. It will take up again at 9 a. m. Tuesday, November 11, continuing until 4:30 p. m. * * *

FIG. 1. Stable and mobile tectonic features are shown here on a clay model of the Mid-Continent-Gulf region.

In this effort to review the progress of oil finding in the Anadarko Basin, it may be as much of interest to petroleum engineers as to geologists to consider the mechanics of crustal deformation as a basis for understanding and evaluating the factors responsible for oil accumulation. Although many of the ideas here have been presented in earlier articles, it will be the object to stress the physical events of a tectonic nature that are responsible for the localization of structural traps, stratigraphic convergence, and facies changes related to the current and future oil possibilities of the region. It is hoped thereby to establish a field of common interest for petroleum engineers who may read this article and to provide perspective that may clarify the origins of regional oil possibilities that might otherwise be analyzed from the narrow viewpoint of local structural detail and fragmentary core analysis. In other words, it is contended that a genetic understanding of the factors responsible for accumulation are a prerequisite to oil finding and reservoir treatment.

It might also be of interest to petroleum engineers to realize that oil geologists share an equal responsibility in utilizing their scientific backgrounds for the practical requirements of participation in what is basically a business venture. They would agree with Henry D. Smyth that although scientists might be more curious regarding the processes of

P 111.3

Anadarko Basin Oil Accumulation

ROBERT R. WHEELER

ANADARKO BASIN—AREA OF PROMISE

The Anadarko Basin is coming into major prominence with accelerating exploratory successes, deep drilling, and communitization of tightly held lease blocks.

Outstanding programs are the extension of granite wash production far beyond Elk City into the Texas Panhandle, exploitation of deep Ordovician reservoirs northward along the Golden Trend, Springer sand prospects of the Wichita front and basin trough, and tremendous expansion of favorable Chester and Morrow possibilities across the Hugoton embayment.

In this article one of the foremost authorities on the region gives a brief glimpse of possibilities of oil and gas discoveries. Realization of increased production will open up new promise for the refiner and the transporter.

nature than engineers, they are none the less concerned with the practical outcome of their geologic theories. As Smyth notes in regard to differences between the philosophy of pure scientists and engineering technologists: "There is nothing inherently evil about being useful . . .".

Thus a geologist responsible for evaluating regional and local oil possibilities at great expense to oil companies, must be just as willing to resist ventures into unfavorable areas as he is to recommend optimistically plays based on limited but positive indications of favorability. In other words he must investigate and face every possible objection to such a program rather than taking the "head in the sand" position of some eminent geological authors who are forever recommending deeper drilling in the central portions of sedimentary basins where abundant evidence may strongly indicate that the objectives should *not* be porous, nor the sites of drilling within the reasonably expectable influence of known tectonic events that might have created structural and stratigraphic traps for oil.

Definition of the Province

As will be explained below, the Anadarko Basin is a subsidiary feature of an originally much larger, earlier Paleozoic prong of that great depositional trough, the Ouachita geosyncline, that bordered the southern margin of the continent (See Fig. 1). Thus, the Anadarko Basin is limited on the south by the Amarillo-Wichita-Arbuckle belt of later Paleozoic mountain building. On the east the basin is bordered by the buried Nemaha granite ridge which roughly bisects the state of Oklahoma, extending far northward into Kansas and culminating southward in the Oklahoma City Uplift related in areal magnitude and age of folding to the Arbuckle Mountains. More ancient positive features, such as the Central Kansas Uplift and the Las Animas-Sierra Grande arching of southeastern Colorado, restricted the northward and westward prolongation of the basin, localizing between them, a northwestern, or Hugoton, embayment. As thus defined the Anadarko Basin covers much of western Oklahoma, the northern Texas Panhandle, southwestern Kansas and the adjoining corner of Colorado. The profile of the basin is asymmetric, sloping gently southward to rise abruptly through a belt of complex faulting into the Arbuckle-Wichita Mountain system. Whereas some 30,000 ft of sediments lie upon basement rocks in the deep trough of the basin, pre-Cambrian granite is exposed a few miles south in the Wichita Mountains. The associated oil possibilities range from Cambrian to Permian in age and cover a region approximately 40,000 square miles in area (somewhat larger than the productive expanse of the Permian Basin of West Texas).

Pre-Mississippian Possibilities

Approaching the geologic history and related oil possibilities with the relationships in mind between the pre-Cambrian domes and the northwesterly invading prong of the Ouachita geosyncline, the sequence of events is as follows. Marine inundation reached the Mid-Continent by Upper Cambrian time flooding across the stable features, reworking siliceous residue that mantled the pre-Cambrian basement rocks and redepositing it as a basal clastic (Reagan sandstone). Doubtless there are older Cambrian sediments at depths beyond even modern drilling ambitions in the Ouachita trough (King 1951) as there are in the Appalachian geosyncline. At any rate there is a striking analogy between upper Cambrian convergence upon the Appalachian foreland (Potsdam of upper New York State) and the Reagan sand overlap of Oklahoma and Kansas and the Hickory sand of central Texas.

Although measured and mapped in the Arbuckle and Wichita Mountains where it varies from 0 to 500 ft of poorly sorted arkosic quartz sand, the Reagan sandstone has not yet been penetrated in the Basin. As a basal sand lapping out locally upon irregularities of pre-Cambrian topography, it may eventually produce by stratigraphic trap or where present and trapped by large structural features, but in the basin proper, depths and uncertainties of sand condition make it a very poor objective. Similar basal Cambrian sands locally produce in central Kansas as, for example, in the Kraft-Prusa district. Here Walters states that porosity is improved by exposure and leaching and that Reagan oil was derived from overlapping Pennsylvanian rocks, conditions not duplicated in the less deeply truncated Anadarko Basin.

This southern Oklahoma embayment must have been a respectable sag by late Cambrian time to have filled with some 6000 ft of Cambro-Ordovician, Arbuckle, limestone. The bordering stable areas (Central Kansas, Ozark, and Llano Uplifts) were deprived by every oscillation of sea level of sedimentary units. Thus, the marginal sections are much thinner, reveal numerous unconformities and the carbonate rocks tend to be dolomitized, leached by subaereal erosion, and improved in porosity.

It is significant that most of the Arbuckle production in Kansas is in areas of truncated dolomite overlapped by potential source beds as is true of the Oklahoma City and Garber production. One infers that favorable porosity and the oil content are secondarily derived from subaerial leaching, exposure, and Pennsylvanian overlap. These prerequisites are not to be expected anywhere in the basin.

As the seas spread farther into the continental interior they encountered aeolian sand which was redeposited in mid-Ordovician time alternately with green clay shales and magnesium limestones to comprise the Simpson (Oil Creek, McLish, and Bromide sandstone) reservoir rocks of the Mid-Continent region.

Of the pre-Mississippian oil objectives, the Simpson group shows far the best record of production and future expectations. The thickest development of porous sands in this group has been penetrated in the southeastern embayment of the basin where it is the major objective of deep drilling in the fault-block reservoirs of the Golden Trend and complex folding of the Eola pool, down faulted from the Arbuckle Mountains. Equally favorable porosity occurs as far west as the overturned Apache fold on the north flank of the Wichita Uplift. These sands deteriorate in porosity northwestward from the Golden Trend especially deeper in the Basin where they are of doubtful commercial quality. The entire sequence thins northward towards the Ozark and Central Kansas Uplifts and was truncated along a northwest-southeast belt of favorable "Wilcox sand" extending over much of central Oklahoma. Similar relations occur along the western Oklahoma-Kansas line notably in Garfield, Grant, Alfalfa, and Woods counties where locally the underlying Viola lime is thin or absent indicating exposure of the Wilcox to leaching and improved porosity. The favorable clastic facies grades westward into unfavorable lime and dolomite beds that so far do not appear attractive as an objective.

In succession the Viola limestone, Sylvan shale and Hunton group of Ordovician to early Devonian age were deposited basinward without significant interruption, converging very gradually upon the more positive areas, where sedimentation was frequently interrupted and accompanied by dolomitization even of the Sylvan formation to produce the Maquoketa dolomite of northwestern Oklahoma and southern Kansas.

Mid-Devonian Regional Uplift

By mid-Devonian time, however, an extraordinary event occurred to interrupt the simple subsidence of the Southern Oklahoma Basin. Not only were the Central Kansas and Ozark Uplifts differentially elevated, but evidently the entire region was raised above sea level following Hunton deposition. It is possible that middle and upper Devonian (post-Hunton) rocks may have been de-

The Author

Robert R. Wheeler is consulting geologist in Dallas, Texas. A graduate of Johns Hopkins University and holder of a PhD from Harvard, he has held geological positions with several major and independent oil companies in the West Texas-Mid-Continent region. Wheeler has written for publications on such subjects as regional oil possibilities, stratigraphic convergence problems and the role of geologists in oil finding. Wheeler is listed in American Men of Science, is a fellow of AAAS, and a member of Sigma Xi, AAPG, and the American Geophysical Union.

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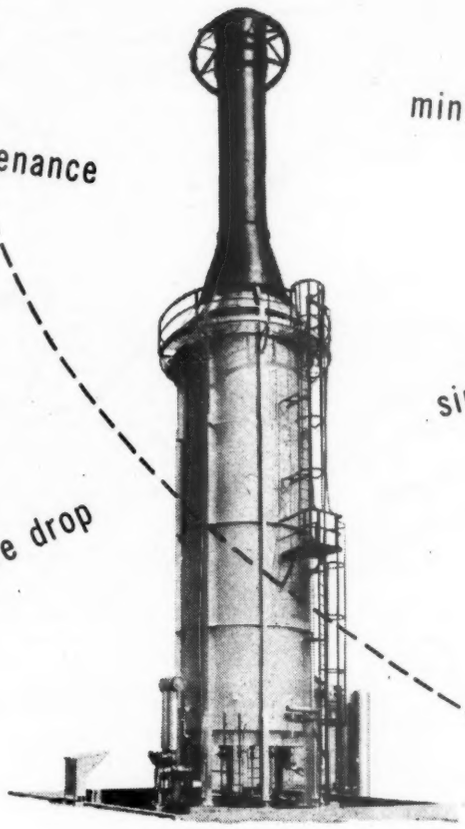

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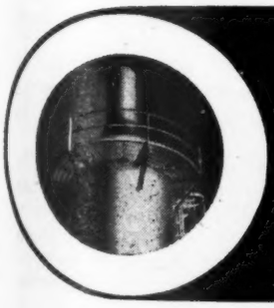

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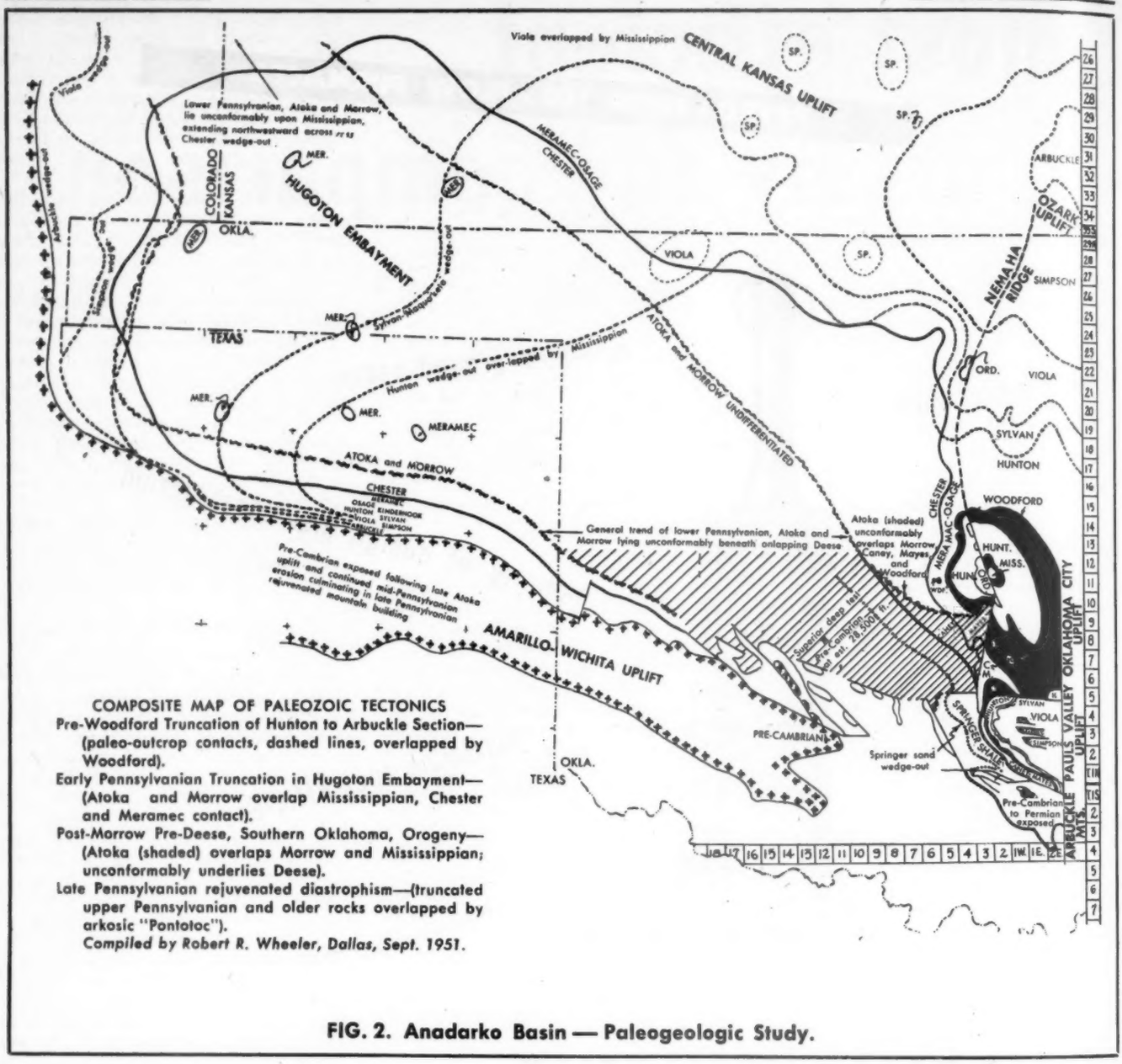


COMPOSITE MAP OF PALEOZOIC TECTONICS

Pre-Woodford Truncation of Hunton to Arbuckle Section—(paleo-outcrop contacts, dashed lines, overlapped by Woodford).

Early Pennsylvanian Truncation in Hugoton Embayment—(Atoka and Morrow overlap Mississippian, Chester and Meramec contact).

Post-Morrow Pre-Deese, Southern Oklahoma, Orogeny—(Atoka (shaded) overlaps Morrow and Mississippian; unconformably underlies Deese).

Late Pennsylvanian rejuvenated diastrophism—(truncated upper Pennsylvanian and older rocks overlapped by arkosic "Pontotoc").

Compiled by Robert R. Wheeler, Dallas, Sept. 1951.

FIG. 2. Anadarko Basin — Paleogeologic Study.

posited in the main (Ouachita) geosyncline.

As a result of this tilting, the Hunton to Arbuckle sequence was beveled off to the north and northeastward so that the Hunton is absent in most of the northern Oklahoma counties and the buried paleo-outcrops of the Sylvan, Viola, Simpson, and Arbuckle flank of the Ozark Uplift (Fig. 2). Relations far to the west are more obscure, but the fact that the Hunton and older rocks wedge-out across the Oklahoma and Texas Panhandles and become increasingly dolomitic indicates that a positive feature (Sierra Grande Arch) lay to the west and restricted extension of the Southern Oklahoma Basin in that direction.

Post-Hunton Events

Evidently the Mid-Continent region was reduced by this truncation to approximately base level for although the overlying Woodford bituminous shale locally compensates in thickness for the topographic relief of the gently folded Hunton and older rocks and although it is true that the Woodford converges northward from a thick and siliceous Ouachita facies to only a few tens of feet in northern Oklahoma and Kansas, still the overall relief is negligible across an area of many thousands of square miles. The abundance of plant spores incorporated in the Woodford and the similarity of color and texture to black residual soils mantling old weathered limestone terrane in warm humid regions suggests that the Woodford north of the Ouachita geosyncline may be more of an ancient soil than a marine deposit. At any rate, the Woodford shale covers the wedge-edges of the dolomitized Hunton and older rocks and being rich in organic material has doubtless been effective as a source bed for these older reservoirs.

The Hunton Play

Quite a few geologists were embarrassed when Ace Gutowsky wanted oil company support in running casing on his Hunton oil shows that opened up the West Edmond field along the east flank of the basin. As they could not see how Gutowsky, drilling on doodle-bug information, could expect to find oil down the west flank of the Nemaha Uplift, it took awhile to get adjusted to the idea that the Hunton group was truncated first by late Devonian tilting of the Ozark Uplift and later by Pennsylvanian arching of the Nemaha Ridge whereby the various members of the Hunton were improved in porosity by solution and trapped by the overlapping Pennsylvanian shales.

Swesnik (1948), as well as McGee and Jenkins (1946), have described the geology of the West Edmond field in great detail.

When the geological fraternity finally became enthusiastic about wedge-edge possibilities of the Hunton group, they initiated a lease play that extended along the inferred belt of Hunton truncation northwestward across the Anadarko

Basin to the Texas Panhandle. Subsequently it has been tested in numerous wells in the latter area, but across all of this spacious belt the only production to date was discovered by the Superior Oil Company in Kingfisher County (Southeast Dover field).

It is hard to understand why many closed structures in northwestern Oklahoma have failed to encounter commercial Hunton production because northward convergence is accompanied by increased dolomitization and favorable porosity. Perhaps the difficulty has something to do with the fact that the underlying Sylvan grades northward into a dolomitic (Maquoketa) facies as do the Viola and Simpson. Unless there are impermeable beds consistently developed beneath the overlapping Woodford shale, there might be a tendency for Hunton oil to have migrated on updip across the similar dolomites of the Maquoketa and older rocks.

Probably the main effort of exploration for Hunton and other pre-Mississippian rocks of the northern shelf will be one of delineating the belts of early accumulation that occurred prior to Pennsylvanian folding. At any rate, oil prospecting in the northern counties may yet find important pre-Mississippian production as it already has in Grant, Garfield, northeastern Major County and southern Kansas.

Mississippian Facies

The oil possibilities of the Mississippian system are mainly restricted to the northwestern portion of the Anadarko Basin. Here, near the northeastern corner of the Texas Panhandle some 2800 ft of Mississippian, predominately limestone, was deposited representing a very complete sequence of Kinderhook, Osage, Meramec, and Chester (in ascending order). In other words, the center of thick lime deposition was displaced far northwest of the axis of previous deposition, due to rapid subsidence of the Hugoton embayment. This sequence is truncated to the northeastward on the flanks of the central Kansas Uplift and westward towards the Sierra Grande arch creating wedge-out possibilities unconformably overlain by Pennsylvanian sediments.

The late Mississippian, Chester series, has shown the most favorable oil possibilities especially within the broad arcuate belt of its truncation where porous sands, sandy lime, oolitic and fossiliferous limestone have already indicated favorable reservoir qualities. Where the Chester is removed by pre-Pennsylvanian erosion the underlying Meramec has been improved in porosity and locally shows favorable oil possibilities.

The Osage tends to be a more siliceous cherty lime section, creating a definite hazard to pre-Mississippian oil ventures and is not a likely oil objective. Neither is the underlying shaly Kinderhook. Where the cherty Mississippian rocks were exposed to subaerial erosion, resistant chert rubble locally veneers this pre-Pennsylvanian erosion surface, and where it has accumulated in sufficient thickness on the flanks of structural or topographic highs in association with source beds, this "Chat" has been a favorable oil objective in southern Kansas and north central Oklahoma.

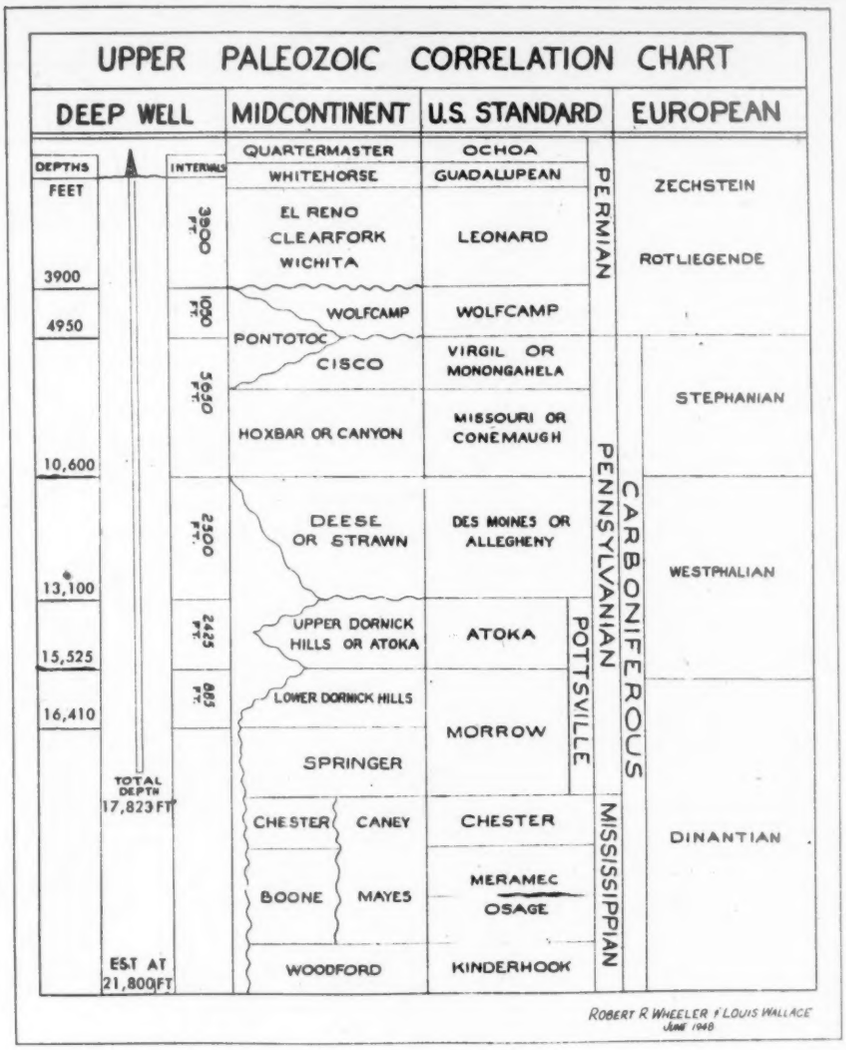


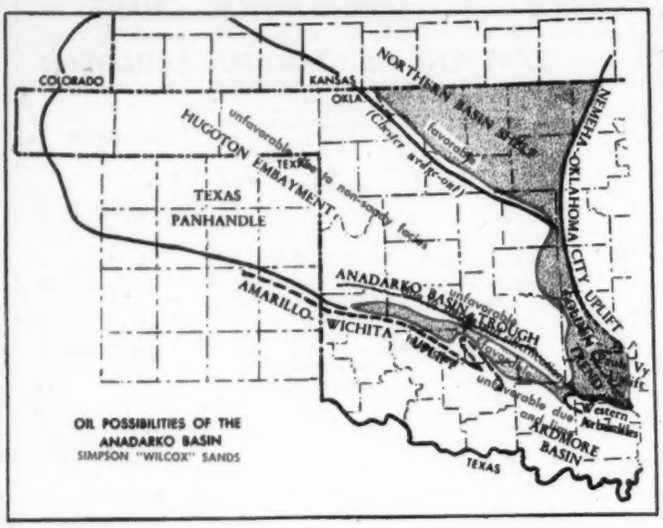
FIG. 3. Upper paleozoic correlation chart.

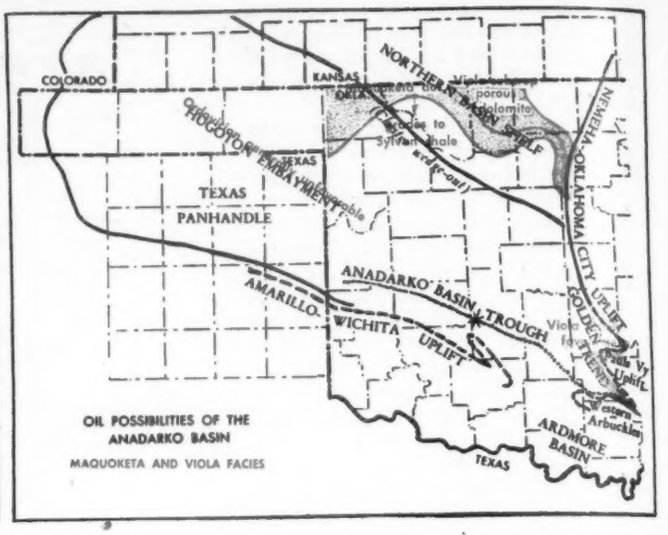
Summarizing the general distribution of Mississippian oil possibilities, these are recognized as deep in the basin as the Continental gas distillate discovery in southwest Major County, the still expanding Ringwood pool of northeastern Major County, the sandy facies of Chester wedge-edge across Woodward County westward to Beaver County, and the contiguous counties of southern Kansas (Adams Ranch, Shallow Water, Nunn, Montano, Aldrich, Kansada, and Arnold pools). This same belt of Chester and Meramec possibilities swings southward into the Texas Panhandle (Lipps pool). The Mississippian grades southeastward into dirty argillaceous limestone and black shales, which are unfavorable for oil.

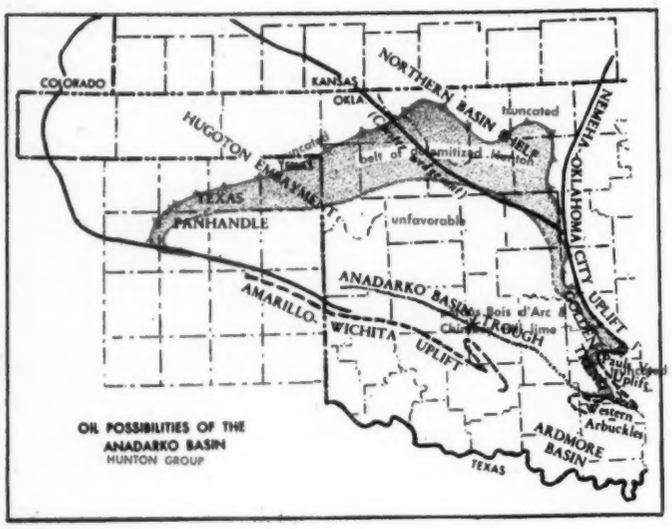
Early Pensylvanian Events

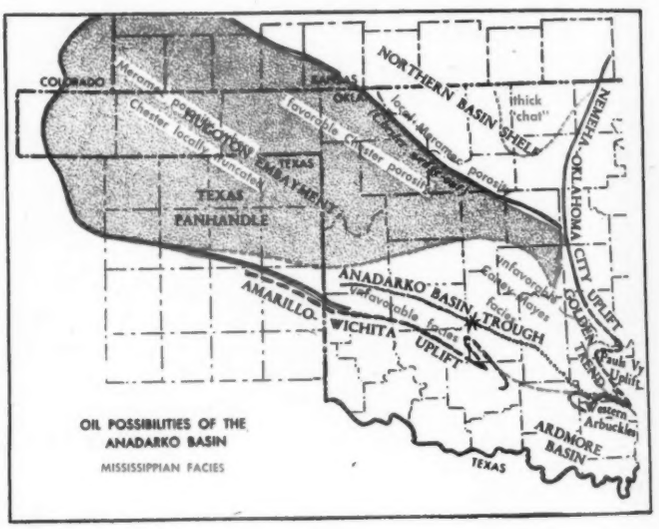
Of the early Pennsylvanian (pre-Deese) reservoirs, the Springer sands of the basin axis and the Morrow sands of the northwestern flank of the basin are the main oil objectives (Fig. 3). The Springer sands, rivaling the famous Wilcox sands of Central Oklahoma, are widely exploited in the Ardmore Basin, but were also deposited in a narrow belt adjoining the Anadarko Basin trough. These objectives constitute the deepest production in the region at the Chitwood pool south of Chickasha. To the east, they are brought up and truncated beneath mid-Pennsylvanian Deese rocks on the flanks of the Pauls Valley arch. To the west, the sands are brought up through sharp folding and faulting to shallower depths along the Wichita Mountain front. They are the objective of tremendous interest in the Cement dome and far westward into Kiowa County. These sands are much less porous to the north, in the Superior deep test (total depth, 17,823 ft), and are not regarded here as a favorable objective across the central flank of the basin.

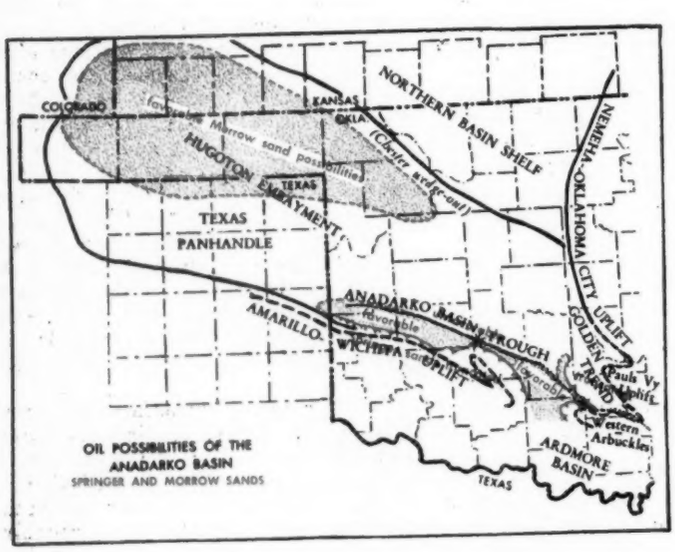
The Springer is unconformably overlain by the shales, argillaceous limes and siliceous sands of the Atoka series in the Anadarko trough. Atoka beds unconformably overlie a Morrow section in the Hugoton Embayment that is roughly equivalent in age to the Springer. So-called "Morrow" sands are responsible for several outstanding recent discoveries: In Ellis County (gas distillate of South Salon pool), in Harper County (South LaVern pool) and Deep Rock's











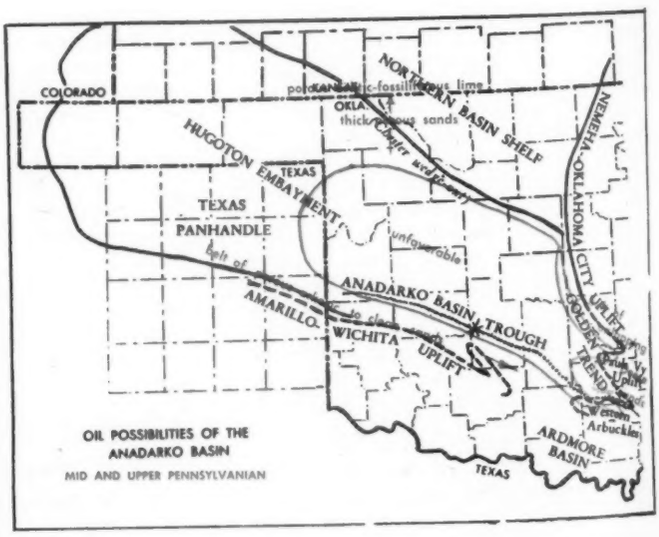


FIG. 4. Distribution of Oil Objectives.

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discovery in Beaver County. "Morrow" sands produce even farther north in Seward and Meade counties, Kansas, and as far west as the Keyes dome in northeastern Cimarron County.

Since the late Mississippian and early Pennsylvanian sections have been interrupted by regional warping and local doming across the northern and western flanks of the Anadarko Basin, this belt is the object of a current exploratory program of major proportions, where accumulating stratigraphic data already permit convergence and porosity studies to delineate belts of wedge-out possibility.

Arbuckle-Wichita Mountain Building

The first episode of true mountain building commenced along the axis of the southern Oklahoma Basin in late Morrow time. There is more evidence bearing upon the resultant deformation and erosion in the Ardmore district where Tomlinson stressed the orogenic significance of basal upper Dornick Hills (Atoka) conglomerates overlying rocks as old as Viola and Simpson in the Criner Hills. Supporting evidence of this early phase of deformation is found in the Anadarko Basin in a down-faulted segment between the Oklahoma City Uplift and the Pauls Valley-Lindsay arch (both of which features came into existence during this orogenic episode). In this depressed area the wedge-edge of lower Springer shale is unconformably overlain by the Moore formation identified by this author as Atokian in age. Here the Atoka is thin, overlaps the Springer, Caney, Mayes, and Woodford, wedging out eastward; whereas, deeper in the basin to the west fossiliferous Atokan rocks penetrated in the Superior deep test reach a thickness of 2400 ft.

Evidently the mountain building movements culminated in late Atoka time because the folding and faulting was followed by subaerial erosion, establishing a widespread unconformity across the deformed Atoka and older rocks. It was during these two stages of early Pennsylvanian deformation that the Arbuckle-Wichita-Amarillo mountain belt was created, elevated along the axis of the preceding depositional trough by folding (locally overturned) and faulted (locally high angle thrusting).

Study of the deformed terrane upon which the Deese seas transgressed following the early Pennsylvanian orogeny shows a number of large newly developed tectonic features (Fig. 2). The Arbuckle Mountain system occupies the central area, consisting of the presently exposed Arbuckle anticline, its buried limb to the north called the Pauls Valley-Lindsay Arch and the central and eastern Arbuckle exposures plunging southeastward beneath the Ouachita overthrust plates. The Oklahoma City Uplift, although not much of a topographic feature, is in reality a buried mountain comparable in size and contemporaneous in origin with the related Arbuckle features. Thus, the axis of the Anadarko Basin terminates within the Arbuckle folds in alignment with the Mill Creek syncline of the exposed Arbuckles, bordered on the northeast by the Pauls Valley and Oklahoma City uplifts and on the south by the western Arbuckle anticline.

Following the orogenic belt westward, the Arbuckle faulting extends as far west into the subsurface as the Doyle pool in Stephens County, but is obscured by northwest-southeast fold axes of the Ardmore Basin until farther west in the more truncated faulted folds (e.g., Cement and Apache) of the Wichita Uplift. The Wichita and contiguous Amarillo buried mountains, extending northwestward into the Texas Panhandle, although more deeply eroded during later Pennsylvanian and Permian deformation, originated like the Arbuckles in early Pennsylvanian time. They are so closely related in facies and the pattern of structural deformation and in their basic relation to the axis of the early Paleozoic deposition that it seems unreasonable to preserve the terminology (van der Gracht 1931) of "Wichita orogeny" for the early Pennsylvanian movement and "Arbuckle orogeny" for the late Pennsylvanian diastrophism. Students of southern Oklahoma geology who have emphasized the major proportions of late Pennsylvanian erosion seem to forget that this later truncation had only the upper and middle Pennsylvanian to remove in order to exhume the early Paleozoic and basement rocks of the older orogenic features.

Actually, erosion that had beveled off and exposed basement rocks prior to middle Deese time, as indicated by arkosic conglomerate (in Garvin County wells) lying upon Hunton and Sylvan rocks, had already been active for a long period of time following late Atoka orogeny and doubtless continued in exposed areas as marine invasion worked ever higher upon the flanks of the newly formed basins. Indeed, erosion must have laid bare broad expanses of pre-Cambrian granite rock in the heart of the Wichita Uplift for by late Deese time and continuing in greater abundance through Hoxbar time arkosic sands were carried northward toward the Anadarko Basin trough to create a belt of granite wash facies of great current economic interest.

The Deese sea, advancing slowly with minor (offlap) interruptions and losing by onlap the older Deese members at its base in contact with the tilted unconformity, reached the higher flanks of the Pauls Valley and Arbuckle arches by the end of Deese time. And whereas an estimated 3500 feet of Deese sediments were deposited in the Anadarko trough, and considerably more in the Ardmore trough south of the mountains, all of the Deese lapped out on the Pauls Valley Uplift and the succeeding, essentially conformable, upper Pennsylvanian, Hoxbar, series progressively overlapped upon the highest areas.

The same general convergence can be observed northward toward the Central Kansas Uplift and northeastward, thinning upon the Nemaha granite ridge and contiguous, central Oklahoma platform. Northward convergence is marked by an interesting change of facies from a basinal shale sequence to a northern basin platform lithology of predominantly limestone character. This is not surprising in view of (1) the limited transportation of clastics derived from the southern highlands and (2) the broad northern expanse of Cambro-Ordovician to Mississippian limestone terrane exposed by early Pennsylvanian uplift upon which the Deese seas advanced and reworked residual limestone debris. Hence, at the Oklahoma-Kansas state boundary where district geological interest tends to reach its lowest ebb, interstate terminology is all the more confused because of the limestone to clastic facies change.

Late Paleozoic Rejuvenation

Considering the problems of late Pennsylvanian mountain building, this episode of compression affected much the same axis as the pre-Deese orogeny, rejuvenating many of the old domes and faults and doubtless creating new ones. If some would argue that this later orogeny was greater in magnitude than the pre-Deese deformation, the evidence in the Anadarko Basin is plain that the deformation did not extend any distance north of the mountains. For example, where the sections are sufficiently preserved to determine a fair answer, as across the Pauls Valley-Lindsay Uplift, the pre-Deese faults were rejuvenated only in the mildest manner, showing possibly tens of feet of mid-Pennsylvanian displacement compared to much greater displacements in the pre-Deese rocks. Moreover, convergence that might indicate tilting and erosion of the upper Pennsylvanian, Hoxbar, rocks occurs on a very minor scale toward the axis of the Pauls Valley Uplift and is by no means typical of an orogenic phase.

Closer in to the Arbuckle and Wichita Mountains where, of course, erosion had proceeded without interruption since early Pennsylvanian time, there is naturally a greater abundance of coarse conglomerate marking the culmination of the total orogenic activity. As a result there was created a conglomeratic facies transitional from early Pennsylvanian to lower Permian in age (called the Pontotoc terrane) and distributed around the flanks of the Arbuckle-Wichita orogenic belt.

It is the object to stress here the significance of many millions of years of erosion and accumulation of coarse rock debris being distributed by non-marine transporting agencies and made available for deposition once the seas encroached upon the eroded terrane. Such was the culmination of the Pennsylvanian mountain building with the mountain-to-basin relief largely obliterated by deposition of interfingering marine (Cisco and Wolfcamp) and non-marine (Pontotoc) sediments of late Pennsylvanian and early Permian age.

By early Permian time the orogenic belt had been fairly well stabilized by compression (folding and faulting), and made resistant to more recent mountain building episodes that affected other parts of the continent. The Anadarko

Basin, more restricted in area than before, subsided mildly to accumulate mid-Permian marine deposits that grade upward into increasingly evaporitic (salt and gypsum) non-marine sediments and red beds of the upper Permian. The northern rim of the basin, replete with pre-Pennsylvanian interruptions of no orogenic significance, reacted to the mountain building epochs of southern Oklahoma by widespread truncation of the Atoka, Morrow, and Mississippian rocks in a series of movements beginning with late Chester, pre-Morrow, folding and truncation, but if the late Pennsylvanian mountain building affected northern Oklahoma and southern Kansas, it cannot be inferred from historic controversy regarding the Pennsylvanian-Permian boundary in Kansas.

Certainly the region least affected by the mountain building activities of the south and the interruptions due to resistance to subsidence of the northern basin platform was the intervening, central flank of the Anadarko Basin. Here there is minimum convergence that might have created stratigraphic oil possibilities, minimum facies change that might have created sedimentary traps and a paucity of structural deformation, very minor folding and inconsequential faulting that could have established structural traps for oil.

Pennsylvanian Possibilities

From the foregoing account of the early and late Pennsylvanian episodes of mountain building, one could generalize the resultant classes of oil possibility as follows: (1) the structural traps in the pre-Deese sequence already discussed (2) the belts of pre-Deese truncation creating stratigraphic traps already mentioned (3) wedge-out possibilities of the onlapping mid-Pennsylvanian sequence (4) the northwestern basin calcareous facies of mid-Pennsylvanian age (5) the arkosic sand belt flanking the Wichita-Amarillo uplift ranging from mid-Pennsylvanian to early Permian in age.

Of these the onlapping Deese sands of the Pauls Valley arch are of especial economic interest having created arcuate wedge-out belts of consecutively younger age to the east (Osborn sand, Hart sand, Gibson sand and more erratic upper Deese sands of east Antioch, Brady, and Northeast Hoover pools). These Deese sands are responsible for much of the "Golden Trend" production of Garvin and McClain counties. In an analogous fashion basal Deese sands lap out along the flanks of the Oklahoma City Uplift where they account for lenticular "Bartlesville" production from Moore to West Edmond.

As noted the rather thick and porous mid-Pennsylvanian sands of northwestern Oklahoma grade rapidly into the more typical limestone facies of southern Kansas. The interfingering has apparently not yet established commercial traps for oil and it still seems that structural closure is the basic prerequisite for mid-Pennsylvanian oil occurrence. However, there are dubious contentions that Carter's Greenough pool in northwestern Beaver County may have tapped a Pennsylvanian reef limestone.

Since Shell's discovery of the Elk City field from upper Pennsylvanian granite wash in eastern Beckham County, the contiguous northern flank of the Wichita-Amarillo uplift has been the focus of tremendous exploratory interest. Carter has established arkosic sand production of Deese age in its Northeast Mayfield discovery farther northwest in Beckham County, and more recently Gulf opened up the Quinduno field in Roberts County, Texas, from three different reservoirs of which the deeper ones are Pennsylvanian granite wash carrying gas distillate and the shallowest is lower Permian dolomite. This might be regarded as the major discovery of the year, extending Pennsylvanian granite wash possibilities some seventy-five miles northwest of Elk City and further broadening the belt of lower Permian potentialities, presently restricted to the Amarillo-Guymon-Hugoton oil and gas production occupying the western and southwestern flanks of the basin.

The mid and upper Pennsylvanian clastics grade rapidly from granite wash to cleaner sands away from the mountain axis so that at Cement the Hoxbar sands are relatively clean and non-arkosic. These sands appear to deteriorate in porosity across the Anadarko trough although Continental is currently testing shows of oil in the Hoxbar series on the Weatherford anticline near the site of Superior's deep failure.

Conclusion

During the five years in which this author has sought to analyze and publish upon Anadarko Basin oil possibilities, the province has come into its own; not only has the frequency of new reservoir discoveries increased, but the area now proved potentially oil bearing has been expanded from the West Edmond, Moore, and Golden Trend plays of the eastern flank to the granite wash possibilities of the entire Amarillo-Wichita uplift and northward to include the vast expanse of the Hugoton Embayment and its late Mississippian-early Pennsylvanian oil possibilities (Fig. 4). As an "Area of Promise," the Anadarko Basin will occupy for many decades the attention of geologists in cooperation with seismologists, converting the flood of new subsurface data into structural and convergence prospects and similarly will engage petroleum engineers faced with problems of deep drilling, completion practices, reservoir behavior, and secondary recovery potentialities.

Considering all that is being written as the solution to increased discovery rate in the basin such as geophysical techniques and the drilling of more holes in the ground, it is the humble contention here that increased attention to the tectonic meaning of new subsurface data will provide the inquiring mind with abundant clues to the disposition of these hidden accumulations of petroleum.

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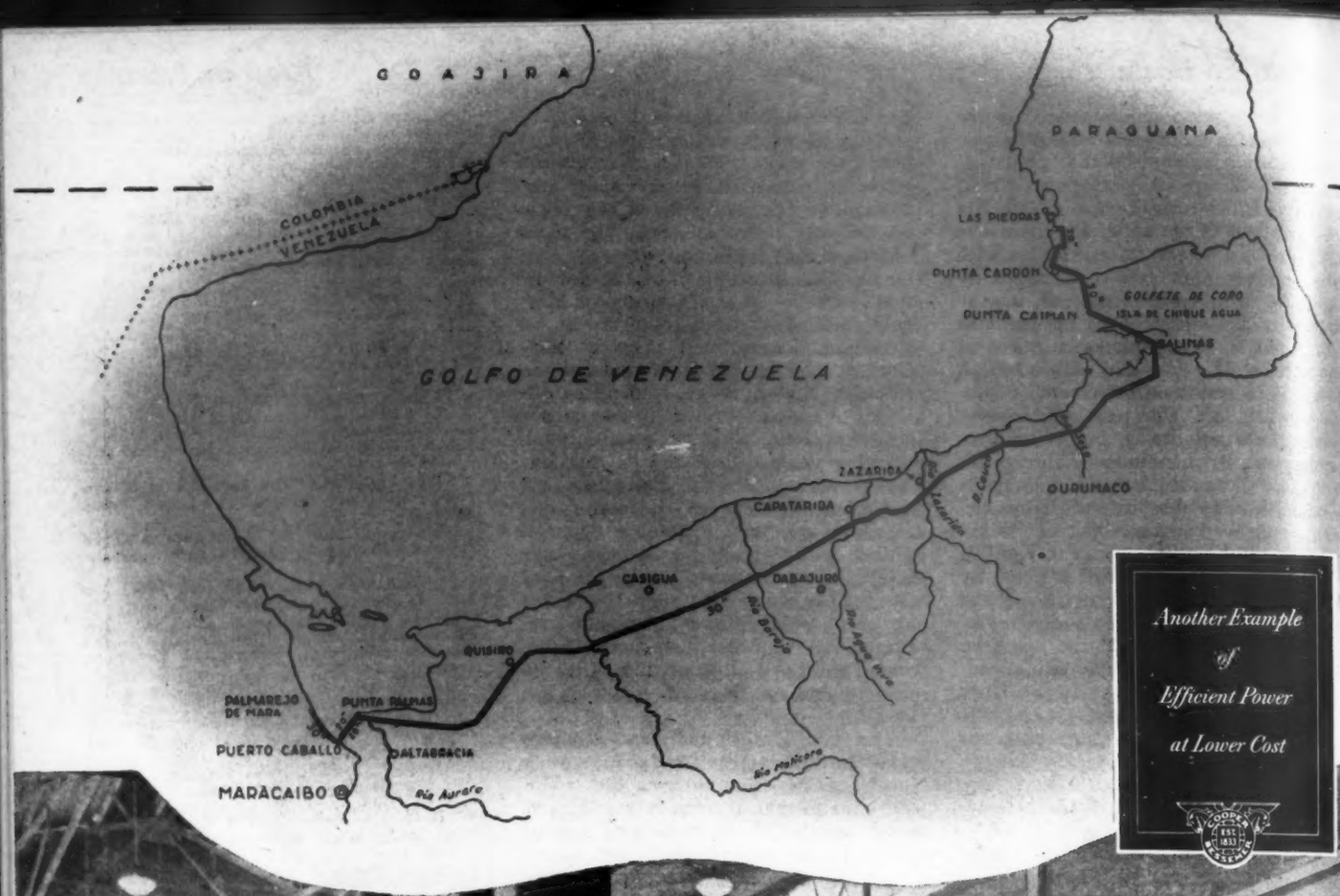

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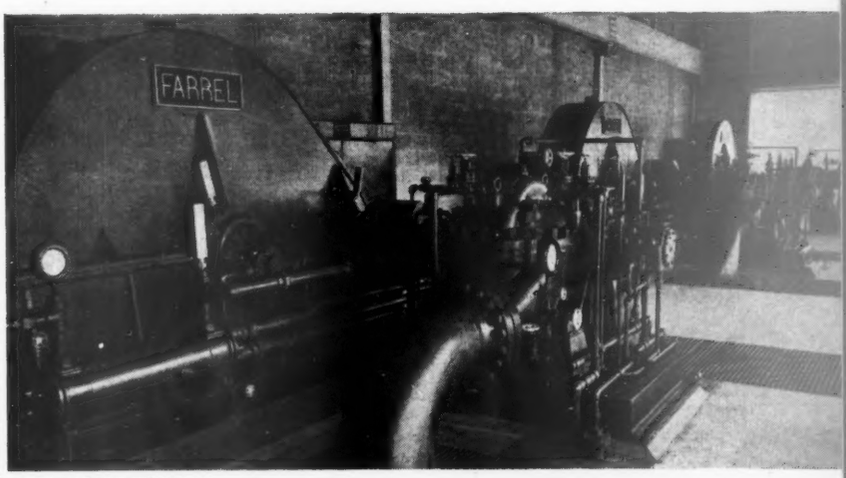
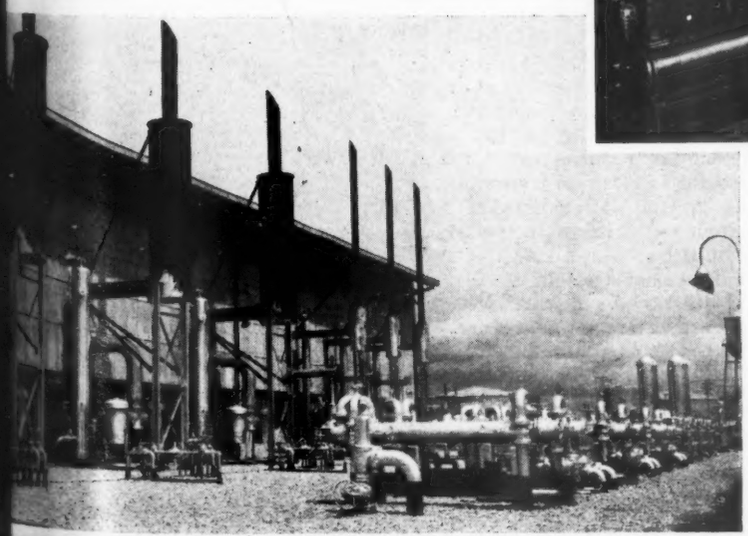
For example, the engines have automatic speed control, with provision for manual control from the main switchboard or from the panel at each engine. The automatic control is governed by the discharge pressure of the station (pumps in series), thus automatically balancing the load between the units. Pipe line safety is further assured by high-pressure, high-flow engine shutdown devices.

On the whole, here's more evidence that for pipe line pumping . . . for *any* stationary service . . . modern Cooper-Bessemers are your best bet.



These three Cooper-Bessemer 1,850 hp LSV-12 Gas-Diesels driving centrifugal pumps, power the new line operated by Shell Caribbean Company. Provision is made for conversion of these units to turbocharged operation, whenever desired, with increasing rating of 2500 hp each.

Below: Exterior view of pumping station showing engine exhaust setup and pipe line manifolding. Line has rated capacity of 250,000 bbs a day.



This view from opposite side of fire wall shows line-up of speed increasing gear units and centrifugal pumps.

by Cooper-Bessemer

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

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EXCLUSIVE

Geological survey party of the Arabian American Oil Company ready to pull out of base headquarters at Dhahran, Saudi Arabia. Stainless steel trailer units serve as office, kitchen, laboratory, and dormitory for the survey party and weight between 20,000 lb and 27,000 lb each when fully equipped.

section that is very nearly circular. It is physically distinguishable by the absence of the heavy tread and squared-off shoulders. As compared to an equivalent highway tire, the sand tire will have less ply layers to increase flexibility. This type of construction permits good sand mobility and it has been observed that the same flexible sand tire stands up well in rough, hard terrain readily yielding to the uneven contour of the ground. The following chart is presented to indicate some of the sand tire substitutions found necessary to "float" automotive equipment on the sand.

Vehicle class	Standard tire	Pressure psi	Sand tire	Pressure psi
Light cars....	5.50 by 15 6.00 by 16	28 – 35	9.00 by 13 9.00 by 15	10 – 20
Light trucks..	6.00 by 16 7.50 by 20	32 – 40	11.00 by 16 16.00 by 16	7 – 20
Heavy trucks.	8.25 by 20 14.00 by 24	45 – 65	14.00 by 20 16.00 by 20 18.00 by 24	20 – 30
Trailer running gear...	Same	"	Same plus 36.00 by 40	up to 30

Using these special round, pliable sand tires and low pressures, the carcass of the tire is permitted to flatten against the sand resulting in extremely large bearing areas. This flattening "bulge" enables the tire to remain on top of the

SAUDI ARABIA

Transportation in Oil Operations

EDWIN J. ZINSZER*

THE following is presented to outline some of the ventures Arabian American Oil Company has undertaken in an attempt to move its oil production equipment over the sand dune expanses of Saudi Arabia. Rubber tired automotive vehicles were chosen to perform the tasks at hand because of the economy of their operation and the expedient manner in which they could perform the necessary feats of transportation. The entirely different types of terrain to be traversed predicated extensive and detailed study and experimentation, the most difficult obstacle was the sand areas. This study, which is still in process, revealed many startling factors, a few of which will be covered in this article.

1. Use of sand tires.
2. Greater heat rejection.
3. Increased area of mobilization.
4. Standardization.

The standard highway and off-road high pressure tires presented too little bearing surface and too little flexibility to keep vehicles from digging in and becoming immobile. For a vehicle to traverse loose sand and sand dunes it must "float" on top of the sand. A tracked vehicle can traverse this type of terrain to a limited extent but requires extensive maintenance due to sand infiltration into exposed mechanisms. It is said that the initial development of the sand tire was predicated on the area of a camel's hoof print and the camel's weight.

The sand tire differs from the standard tire in many respects. It has a larger

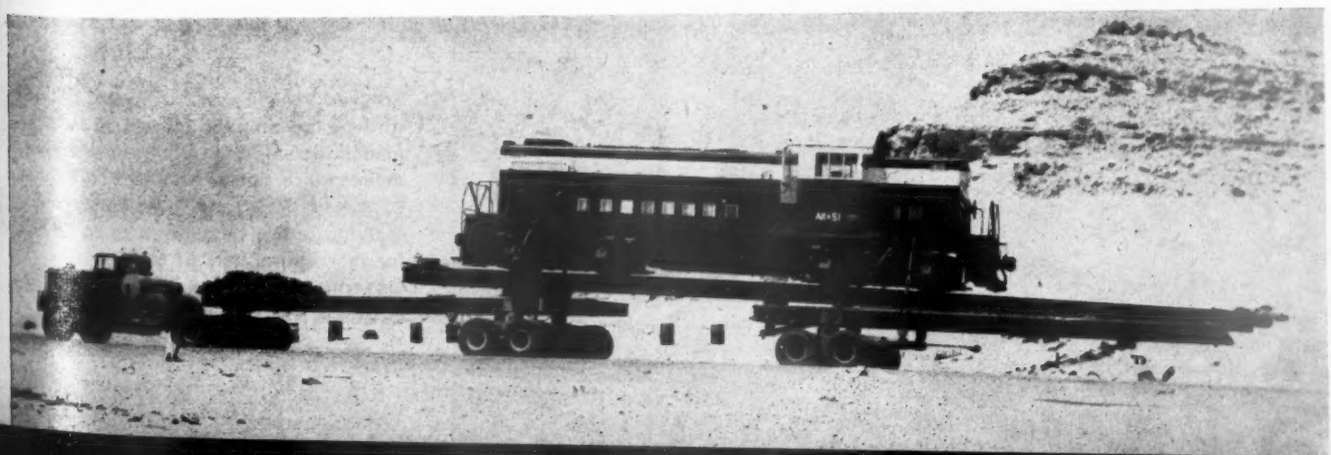
A 36.00 by 40, 32-ply tire used by Aramco on chasis that moves intact, 136-ft drilling rigs from one location to another. Each tire is capable of handling 75,000 lb of load. Usual weight of rig load including engines, rotary, drawworks, etc., is about 150 tons. These tires pull easily through sand. Complete load is towed by two D-8 cats.

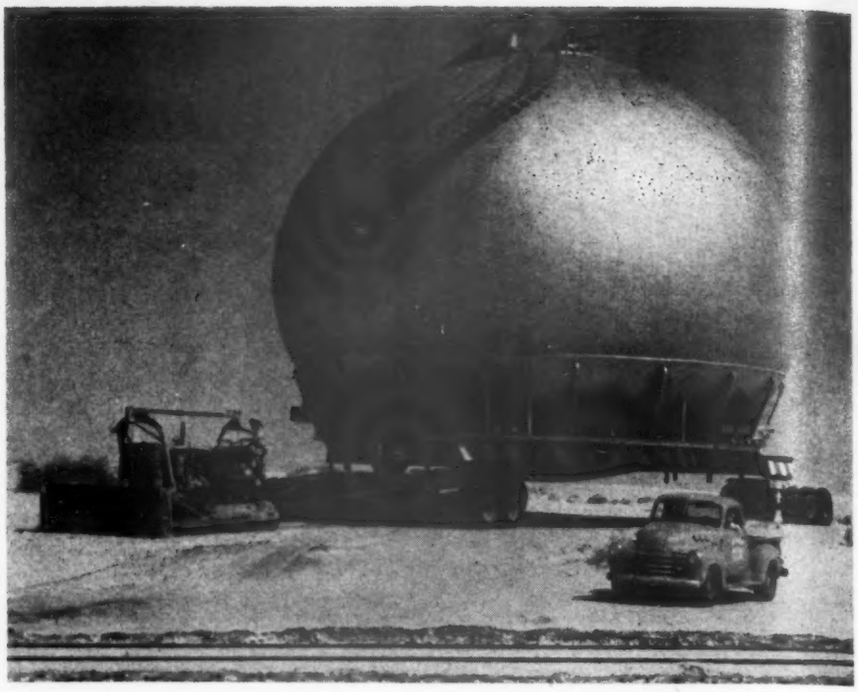
*Transportation engineer, Arabian American Oil Company.

Horizontal gas trap weighing 50 tons. Actual move of this trap was from Ras Tanura to Abqaiq, about 100 miles.

Left, above, Aramco has performed unusual feats of transportation in the Saudi Arabian operation. This 50 ton, 32 ft by 42 ft prefabricated house was jacked up, placed on steel sills supported by a standard dolly and a heavy truck and moved 680 miles across the desert.
Right is a Dodge powerwagon and a big 300-hp brother.

Above, left, increased radiator capacities and frontal areas are based on the relationship of 2 sq in. of frontal radiator surface for every 1 cu in. of engine displacement. This gas truck checks out with dispatcher at Ras Tanura and will head for Riyadh with a load of gasoline for the Saudi Government. Right, Saudi Arab truck driver in one of Aramco's dump trucks at Dhahran, Saudi Arabia.
Below, a 125-ton locomotive — on cradle (with rails on cradle) was moved 50 miles overland in 6 hr. This outsize load was moved with a 6 by 6, 290-hp tractor in front and the same type of pusher behind.





A 60-ton spheroid tank measuring 52 ft in diam was moved 65 miles across the desert from Abqaiq to an Ain Dar gas-oil separator plant. The move took 3 days and is believed a "first" in moving tanks of this kind any significant distance from original construction sites.

sand thus inhibiting "digging-in" with the consequential immobility. Using sand tires it is possible for vehicles with train loads of up to 250,000 lb to travel over shifting, soft sand dunes with slopes of 30 per cent.

The ability to traverse over 30 per cent slopes requires much more than sand tires and thus presents a second problem in sand operation. All wheel drive is imperative for sand operation for heavy vehicles. To obtain the greatest area of operation over the type of terrain experienced in Saudi Arabia high horsepower and great final reduction to all wheel drive is a requirement in large vehicles. Units must have a wide gear selection to permit high reduction and still maintain reasonable on-road speed. The engine power requirements are dictated by the terrain and the fact that the rolling resistance of a tire in sand is four to ten times that of a standard highway tire on a good road. Regular schedules are maintained with vehicles of 300 hp hauling 50 tons over open dune area for as great a distance as 300 miles. The only vehicles that can approach sand operation with nominal horsepower and only two wheel drive are sedans and very light pick-up trucks. The method of surmounting dune obstacles for these vehicles is to approach them at high speeds and rely on momentum to supply the necessary effort. In some instances, such as on exploration parties in unknown territory, a 4 by 4 vehicle is close by to tow the 2 by 4 unit if it "digs in."

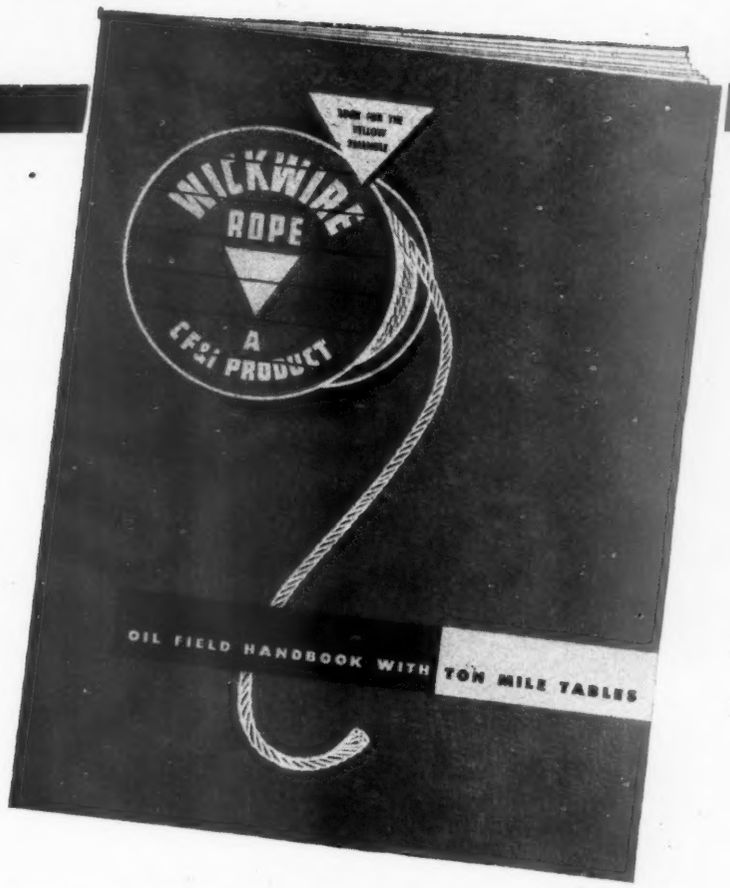
The associate problem with higher horsepowers is sufficient cooling. Vehicles operate in an ambient temperature of 125 F with ground temperatures as high as 145 F. It should be noted that vehicular cooling systems because of their design and the location of the radiators utilize the low hotter levels of air for cooling purposes. This has necessitated increased radiator capacities and frontal areas based on the relationship of two square inches of frontal radiator surface for every one cubic inch of engine displacement (the U.S.A. standard is less than half of this amount.) Incorporated with larger radiator size is the use of oversized fans with increased number of blades and fan shrouds. High ambients with the possibility of tail winds dictate the need of these larger fans and absolute necessity of fan shrouds. Actual experience indicates that an increase in the rows of cooling tubes over four does not improve the cooling efficiency in comparison to a proportional increase in frontal area. In desert operation 10 to 12 per cent of the engine horsepower can be economically used for cooling purposes.

Surge tanks have a definite place in cooling water conservation. Without the surge tank, volume increase due to elevated operational temperatures would be lost resulting in less capacity for heat dissipation. The surge tank requires the use of a sealed cooling system. The use of pressure caps has been eliminated because of the possibility of scalding due to a rapid removal of the cap from a hot pressure system. The alternative is the safer water-tight but not pressure-tight water cap.

Additional protection is given to the engine through the use of a thermal cut out. Engines so equipped will not operate above a predetermined temperature. Protection to the vehicle necessitates a judicious allocation of thermal cut outs. If situated in the block or radiator

Tracked vehicle can traverse this kind of dune terrain in Saudi Arabia to a limited extent, but requires extensive maintenance due to sand infiltration into exposed mechanisms. This bulldozer is clearing a path through dune country for the right-of-way of Saudi Government Railroad during early construction days.

ROPE



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header they must be set high for operational efficiency; when the engine cuts out the temperature continues to rise, and then cools very slowly. The location of the cut out in the surge tank permits a lower setting, more rapid cooling and provides warning signals — the first indication is a spout of steam, the second is rusty water squirted on the wind shield.

To increase the engine life an oil pressure cut out is also used. This fuse plug operates primarily on oil pressure and it will also stop the engine when the viscosity drops too low from excessive temperature.

The high alkaline content of the available water presents complications due to internal corrosion and clogging. Chemically processed water, distilled water, and such can alleviate this situation but supplying it at service stations presents a problem in logistics.

The remoteness of the domestic source of supply and the field of operation requires the facilities of large storehouses completely stocked to keep vehicles running and off the deadline. To reduce the necessary storage facilities to the smallest size possible, it was necessary to enter a wide standardization program. By using similar components on various vehicles it is possible to store different models of a particular item. To elucidate, one organization provides the sedans and light trucks that cover four different vehicles: Sedans, one-ton trucks, two-ton trucks, and 4 by 4 units (all wheel drive). Thus in four different classes of vehicles one complete engine is used, three rear end assemblies, three transmissions, and three different wheels. The heavy units are basically two vehicles, all models being comprised of components of the two basic units yielding five models of heavy duty trucks. In addition there is interchangeability between the two basic units.

All trailer units use a standard running gear whose wheels are the same as the heavy truck wheels. One universal dolly is used on all trailer equipment. A present program toward the goal of fewer spare parts, less maintenance and less down-time is the substitution of a box walking beam for the now standard spring pile. This is possible without sacrificing roadability as one sixteenth inch deflection of the spring pile occurs at four inches deflection of the tires — the spring is actually a walking beam. Using a box section unit eliminates the necessity of spring leafs, spring shackels, spring bolts, spring wedges, etc., decreasing greatly spare parts inventory and simultaneously the number of parts that can fail and cause down-time.

The availability of a unit reconditioning shop permits unit repairs and replacement of components reducing down-time. A malfunctioning component is removed from a vehicle and immediately replaced with a reconditioned component. Thus the vehicle is back in service while the disabled component is under repairs. The result is a smaller inventory of spare parts, ease of training of mechanics, unitized reconditioning, and service repair.

Using the aforementioned special equipment it is possible to perform unusual feats in transportation over rolling dunes and roadless terrain. A 50-ton house has been jacked-up, placed on steel sills supported by a standard dolly and a heavy truck, and moved 680 miles across the desert. A 125-ton locomotive has been placed on cradles mounted on 4 standard dollies and hauled 50 miles overland at six miles per hour by a large tractor truck. Exploration caravans, comprising multi-trailer units (utility trailers, 10 man sleeping trailers, office trailers, mechanics trailers, etc.) three to five units per string, each unit 30 to 40 ft long, train out for exploration areas. A standard 136 ft drilling derrick has been placed on a platform with outriggers supported by standard dollies. The total resulting unit towered 166 ft from the ground and grossed approximately 220,000 lb. The tires used for this movement were 36.00 by 40 with 37,000 lb per tire. In addition to the unitized derrick and the draw works, the unitized pumps weighing 250,000 lb are separately mounted on dolly supported outriggers and all components are moved to new sites.

Further details concerning desert modifications for automotive equipment can be found in "Automotive Transportation in Saudi Arabia" by R. C. Kerr, which was presented at the SAE National Transportation Meeting, New York, October 16, 1950. * * *

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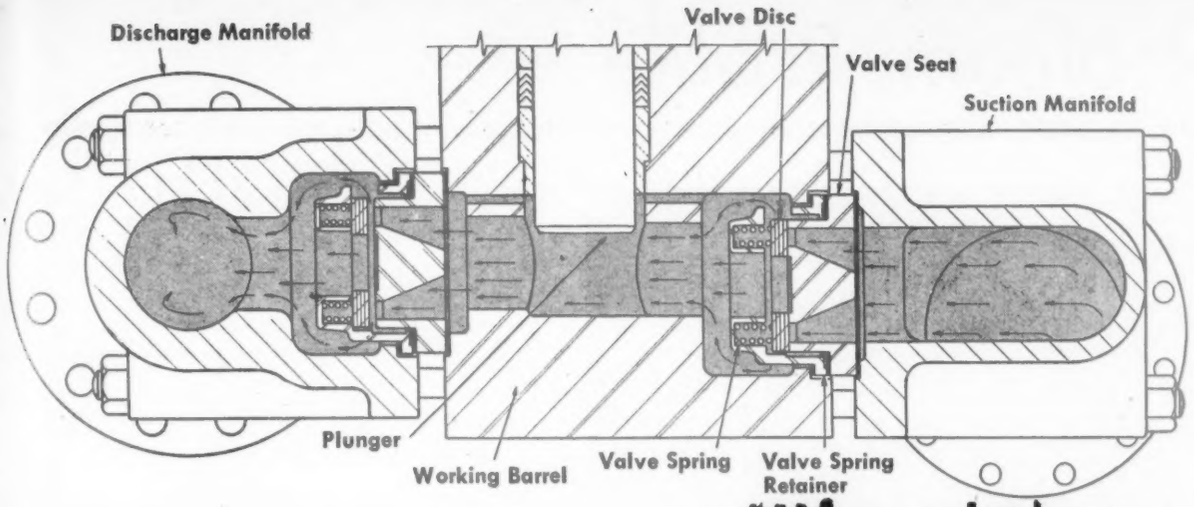
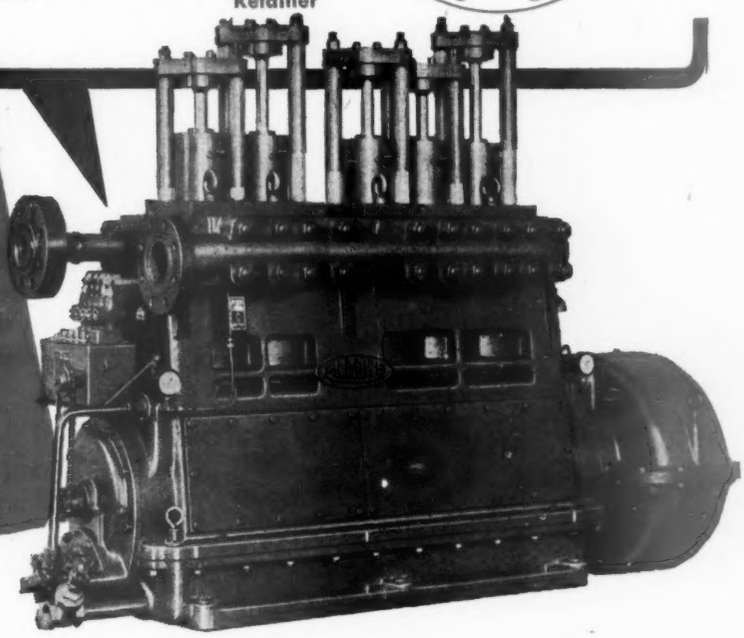


ENGINEERS: Check these points of Aldrich Direct Flow Design



Aldrich engineers eliminated two right-angle turns in the fluid-end. Now, liquid passes from suction to discharge manifold in a *straight line.* That gave the Direct Flow Pump its name, and set up a whole new concept of pumps, pumping, and pump maintenance. It all adds up as follows:

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Petroleum Profile

EDWARD F. MORRILL

President

Mid-Valley Pipeline Company

"If a man love the labor of any trade, apart from any question of success or fame, the Gods have called him."

Were Robert Louis Stevenson alive today, he could well have had Edward F. Morrill in mind when penning these words. Because if the Gods ever called a man to pipelining, that man is the president of the Mid-Valley Pipeline Company!

"Ed"—a worker in every sense of the word—has a keen analytical approach that enables him to get a good grasp of both immediate aims and long range goals of any project he tackles, brilliant engineering talent, and that rare ability to work *with* people and *get things done.*

It was at Case Institute of Technology in his native Cleveland that this energetic, friendly Ohioan first displayed the spirit of "go-at-it-tiveness"—the knack of getting things done efficiently and quickly, without fuss or fanfare, bombast or browbeating—which has figured so importantly in his career.

Upon graduation with honors in 1929, the young civil engineer went to work for a telephone company. Three years later, he joined The Standard Oil Company (Ohio); he's been an oilman ever since.

Starting as a service station employee, Ed was transferred shortly thereafter to special bulk station work in Akron, then later was brought back to Cleveland. One Sohio job served as a stepping-stone to a more important one; he progressed through positions in home office bulk station sales, refined products distribution, and transportation department special assignments.

In 1938, Morrill was promoted to assistant manager of the transportation department; in 1941, he became chief engineer of Sohio's pipe line and river operations, and in 1944, he was made directly responsible for these functions for Standard Oil of Ohio and two of its subsidiaries, Sohio Pipeline Company and Sohio Petroleum Company.

Morrill became vice president of Sohio Pipeline Company in 1946, was elected its president in February, 1950, and was chosen to head Mid-Valley 7 months later.

At Sohio Pipeline, Ed was in charge of the company's 1700-mile gathering line operations in Illinois, Indiana, and Kentucky, handling 64,000 bbl daily. Under his direction, the company operated a 400-mile 6-in. line from Stoy, Illinois, to Mantua near Cleveland, Ohio, and two other lines—an 80-mile 10-in. trunkline from Salem to Stoy, and a 240-mile 12-in. pipe line from Stoy to Lima.

At Sohio Petroleum, Morrill directed barge transportation operations. In 1948, the company operated a fleet of 13 towboats and 40 river barges moving chiefly crude oil some 6-billion-barrel-miles per year. Valued at $2,200,000, Sohio's fleet was the nation's largest inland waterway transporter of oil until the construction in 1949-1951 of the 1000-mile Texas-to-Ohio Mid-Valley underground artery, which eliminated for Sohio the need for river transportation.

Prior to joining Mid-Valley, Morrill thus was responsible for all transportation operations for Standard Oil of Ohio and its subsidiaries—an activity that required facilities in 13 states representing an investment exceeding $22,000,000 and engaging some 750 employees.

Because of his outstanding performance in these posts, he was selected to spearhead the gigantic task of building the $60,000,000, 1000-mile Mid-Valley Pipe Line Company system, which was in partial operation in 1950, and full scale operation by 1951.

It is the human qualities, as much as his keen engineering and unusual organizing abilities, that have earned for this soft-spoken, quick-thinking, fast-working pipelining dynamo an important niche in the hearts of his associates and employees, and also have made him an effective contributor to contemporary industry progress. ★ ★ ★

Anadarko Basin Possibilities

Portions of three neighboring states, Texas, Oklahoma, and Kansas, are encompassed by the vast Anadarko Basin. The sedimentary deposits in the basin reach a depth of 30,000 ft and the total area extent is 40,000 square miles.

The basin is an "area of promise." The complex geology has not been fully determined as yet. In order to develop the area effectively a more detailed geological picture is required. A more precise interpretation of the basin proper is under way.

The reason why the Hunton formation in northwestern Oklahoma is commercially nonproductive is an unsolved problem. Favorable factors exist — northward convergence with dolomitization and porosity. Is migration the answer?

Outstanding recent discoveries have been made in the basin. For example, gas distillate in the South Salon pool in Ellis County, South LaVern pool in Harper County, and the Deep Rock Oil Company discovery in Beaver County.

A distinct flattening of the basin occurs in Beaver County, and considerable activity centers around this particular area at the moment. It was here that early in 1952 the Carter Oil Company made an important discovery in the Greenough pool. The total depth of the well was 5867 ft. A 3000-gal acidization was performed and a 19-ft limestone pay section had a daily initial production of 936 bbl oil and 1845 mcf on a 33/64-in. choke.

Wildcatting is conducted throughout the northwestern counties of Oklahoma and stratigraphic trap accumulation is sought.

The northern flank area of the basin is where stratigraphic traps are most probable.

Drilling practices in the Anadarko Basin call for a close supervision of the drilling fluid. Sections of difficult shale, anhydrite or salt, and zones of lost circulation and high formational pressures are present.

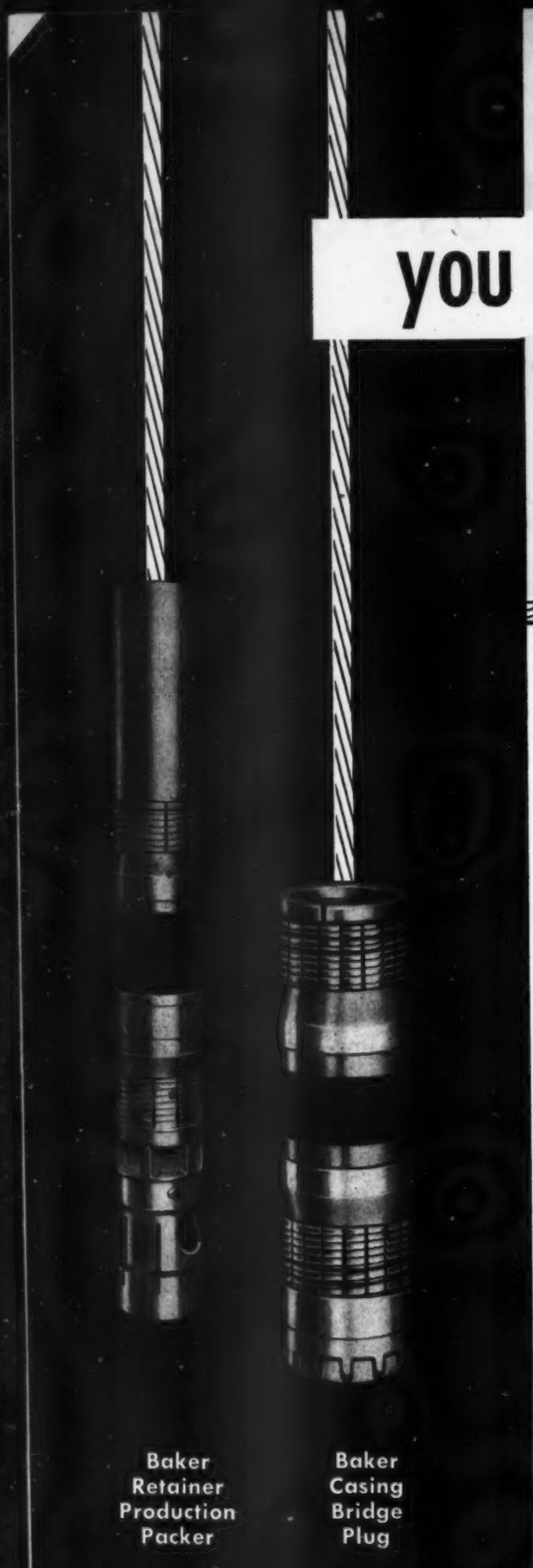
In southwestern Kansas and the Oklahoma Panhandle for drilling below the salt section an oil emulsion mud is used. For this area the mud program is designed to obviate the inclusion of an intermediate casing string. In West Central Oklahoma, however, the general practice is to set a 3100-3600 ft intermediate casing string through the salt and anhydrite formations.

Production possibilities from western and northwestern Oklahoma may eventually equal that of the eastern part of the state. The matter is, however, speculative.

R. Wheeler, an eminent authority on the Anadarko Basin, aptly summarizes the basin in his article, Page A-45.

"As an 'area of promise' the Anadarko Basin will occupy for many decades the attention of geologists and seismologists, converting the flood of subsurface data into structural and convergence prospects and similarly will engage petroleum engineers faced with problems of deep drilling, completion practices, reservoir behavior, and secondary recovery potentialities."

The correct interpretation of the tectonics is the key to open the possibilities of petroleum accumulation in the Anadarko Basin.—J. M.



Baker Retainer Production Packer

Baker Casing Bridge Plug

you save ...TIME AND MONEY when AND TUBING

THE BEST PROOF of these savings is the increased number of wire line setting jobs by oil operators everywhere. For example, out of the total number of Baker Casing Bridge Plugs set during the year 1951, 71% were run on wire lines.

AND REMEMBER that all these *SAVINGS INCREASE* as *WELL DEPTHS INCREASE!* Out of all the Baker Packers set on wire lines during a recent six-month period, over 22% were set at more than 10,000 feet. The saving in round trip time over using tubing or drill pipe is an important item; and even more important is the elimination of wear and tear on tubing when a wire line is employed for setting.

Consider, too how wire line setting helps you to avert premature setting of either device, caused by junk or other debris in the hole. And don't overlook the fact that in many instances both the gun-

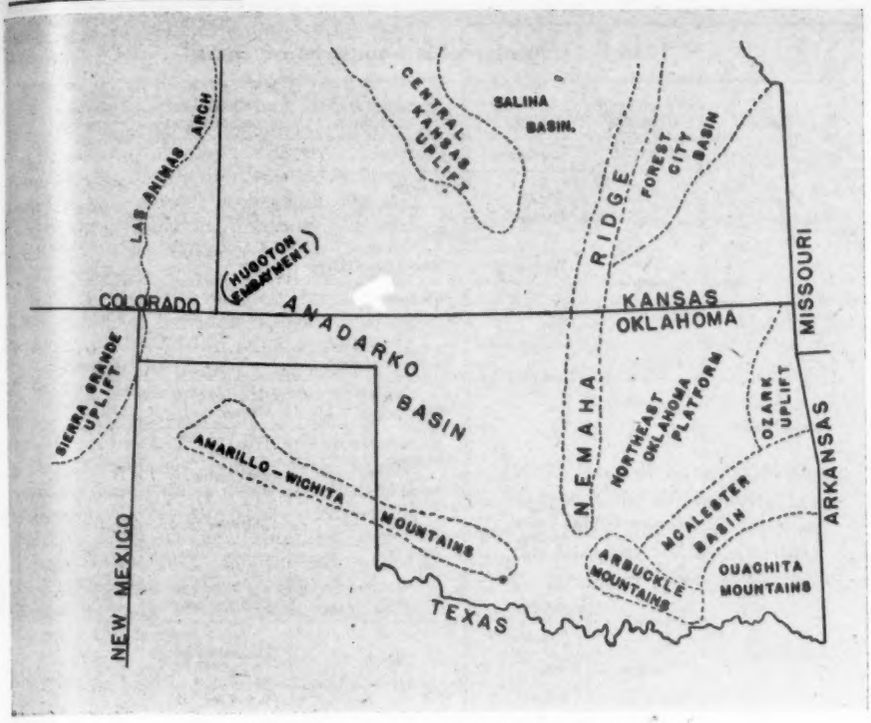


FIG. 1. Outline map showing location of Anadarko Basin and the adjacent structural features.

The Author

Carl A. Moore is an associate professor of geology and is chairman of the school of geological engineering at the University of Oklahoma. After receiving his doctorate in geology at the State University of Iowa in 1940, he joined Standard Oil Development Company (Standard Oil Company of New Jersey) as research geologist. From 1942-1946 he worked as a field subsurface geologist for the Carter Oil Company in Seminole and Oklahoma City. Chief fields of interest and research are petroleum geology and subsurface geology, with special reference to the occurrence of oil in sedimentary basins, and to the techniques applicable to subsurface geology.

P 330.

Stratigraphic Trap Possibilities

Prominent flattening of formations occurs in Beaver County and this area is experiencing active drilling

CARL A. MOORE

It has been said that there will be as much oil found in western and northwestern Oklahoma as has been found in eastern Oklahoma. A look at the production map of Oklahoma may lend some doubt as to the truth of such a statement.

It may be pointed out that western and northwestern Oklahoma have yet to be explored as thoroughly as has eastern Oklahoma. Neither is there the favorable depth consideration in western Oklahoma that is to be found in eastern Oklahoma, where the Simpson group of rocks (containing the "Wilcox" sand) may be completely penetrated above depths of 5000 ft. With the modern methods applicable to oil finding, however, and with a better understanding of the subsurface geology of the vast area of northwestern Oklahoma, there is likelihood that western and northwestern Oklahoma may yield much that is of promise.

Current activities in northwestern Oklahoma are being pushed in Beaver County, with sporadic wildcat attempts scattered through the northwestern counties where stratigraphic wedge outs are being mapped and explored.

On the basis of geographic features and structural relationships, Wheeler (1947) has subdivided the Anadarko Basin into 5 provinces: (Fig. 3) (1) Anadarko trough; (2) southeastern embayment; (3) central basin flank; (4) northern shelf, and (5) Dodge City embayment. This latter province is called the Hugoton embayment by Maher and Collins (1949).

The area to be discussed here has been limited to that portion of the Anadarko basin lying north of Twp. 16 North to the Kansas line, and west of Rge. 9 West, to the Texas line, and also includes Beaver County. This area then lies in the Hugoton embayment, on the northern basin shelf, and extends southward onto the central basin flank. Specifically, it includes Beaver, Harper, Woods, Alfalfa, Ellis, Woodward, Major, and Dewey counties, and parts of Roger Mills, Blaine, and Kingfisher counties.

EXCLUSIVE

Basin Setting

The Anadarko Basin is asymmetrical in outline (Weeks, 1942), as shown on Fig. 2, and is delimited on the north by the Central Kansas uplift, on the east by the Nemaha ridge, on the south by the Wichita Mountains, and on the west by the Sierra Grande-Las Animas arch. Fig. 1 illustrates the geographic location of the basin. In Beaver County there is a prominent flattening of the normal basinward east dip, west of which the sediments are much thinner and show evidences of having been deposited on fairly stable platforms in shallow water. This would tend to move the basinward edge of sedimentation at least as far east as Beaver County, and

this has influenced the deposition of many of the formations in northwestern Oklahoma.

On the south flank of the basin (Fig. 1), along the Amarillo-Wichita mountains, the rocks are highly folded and faulted, and dip northward into the trough of the basin at a steep angle. This is the borderland side of the basin. The axis of the basin lies some 25 miles north of granite outcrops in the Wichita Mountains. The trend of the structures along the south edge is essentially parallel to the mountains indicating that these structures are the direct result of the upward movements in the mountains of the borderland.

The northern flank of the basin, on the stable foreland side of the basin, does not seem to have been particularly affected by pronounced structural uplifts, and the rocks along this flank exhibit a monoclinal dip away from the Sierra Grande-Las Animas arch, and the Central Kansas uplift, at an angle usually less than one degree (Maher and Collins, 1949), with minor structures that hardly interrupt the regional dip.

Thus the foreland side of the basin remained very nearly positive during much of the Paleozoic era and received a much thinner section of rocks than did the mobile borderland area to the south. As a result, there are more uncomformities along the northern flank, thinner sections, and shallower water deposits. Furthermore it can be shown that because of the minor degree of structural uplift, the wedge belts of rocks, and the numerous unconformities, stratigraphic oil is to be expected along the northern flank.

Regional Geology

The northern flank of the Anadarko Basin has undergone a history quite unlike that of the Wichita Mountain front to the south (Table 1). Ordovician rocks are found in maximum thicknesses along the mountain front, and they thin appreciably toward the north, toward the foreland side of the basin. Limestone and dolomite deposition in the Arbuckle group and the Viola formation is continuous from the south onto the northern flank, while the Simpson group, which is over 2700 ft in aggregate thickness in the southern area, thins to a few hundred feet to the north.

TABLE 1. Stratigraphic nomenclature chart.

Period	Southern Oklahoma	Series	Group	Formations and members	Kansas series
Permian	Pontotoc	Guadalupe	Whitehorse		
		Leonard	El Reno		
			Enid		
		Wolfcamp	Chase-Council Grove		
Pennsylvanian			Wabaunsee		Virgil
			Shawnee		
	Hoxbar		Lansing-Kansas City		Missouri
	Deese		Marmaton	"Big Lime" Oswego	Des Moines
			Cherokee	Prue	
				Bartlesville	
	Dornick Hills	Atoka		"Morrow sand"	
		Morrow			
	Springer				
Mississippian	Caney	Chester		Manning zone	
		Meramec		Mississippi Lime	
	Sycamore	Osage			
	Woodford	Kinderhook		Woodford	
Devonian Silurian	Hunton		Hunton Terrane	Hunton	
Ordovician	Sylvan			Sylvan	
	Viola			Viola	
	Simpson		Simpson		
	Arbuckle		Arbuckle		

The Hunton maintains its usual character of limestone and dolomitic limestone, and the Bois d'Arc member, which is so well defined in the southern area and along the west flank of the Nemaha ridge, is mostly dolomite showing varying amounts of porosity. To the north, however, the Hunton was eroded following post-Hunton uplifts, and is confined to the basin proper. See Fig. 5.

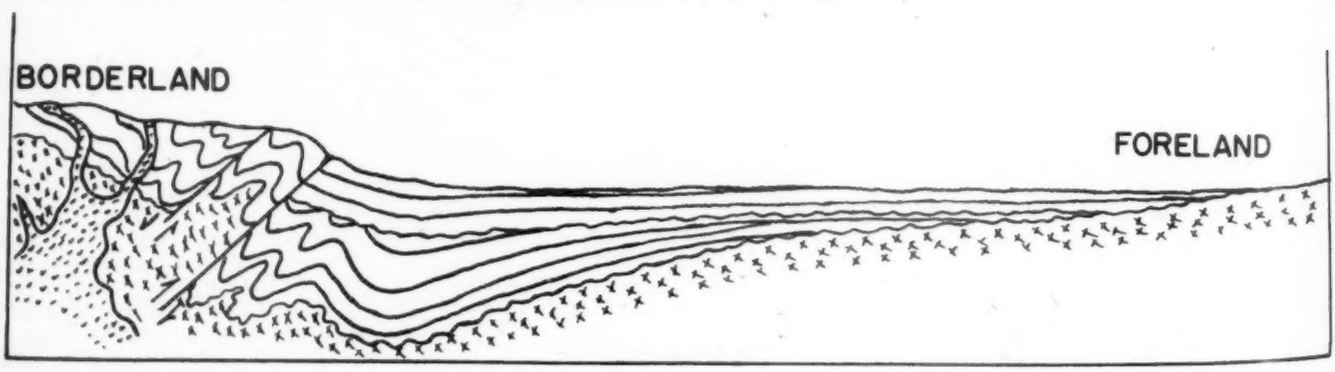
Woodford brown, spore-bearing shale and Kinderhook dark limestones, often difficult to pick out in samples, are readily distinguished by the abnormally low self-potential diagram on the electric log.

Two facies of the middle Mississippian, Osage, may be recognized: A basinward facies consisting of gray to brown siltstones that are calcareous and dolomitic, and carry varying amounts of chert; and along the northern shelf of the Anadarko Basin and in southwestern Kansas there is the siliceous facies of the middle Mississippian that is gray to dark gray, very finely crystalline to semi-dense limestone that carries translucent and blue-gray chert. This is the so-called "Mississippi Lime" of the drillers, and it is extremely difficult to drill. Stories are common of the number of bits used to penetrate this thick sequence of siliceous limestones — of the "bits per foot," loss of circulation, and the frequent drilling difficulties.

The middle Mississippian rocks extend completely across the area under study, and on the platform areas to the northeast, the Cherokee shales (Pennsylvanian) rest on this limestone.

Following the siliceous limestone sequence of the middle Mississippian, the Meramec series is represented by the Caney shale of the basin proper — a

FIG. 2. Diagrammatic cross-section of an ideal asymmetrical basin. (After Weeks, 1942).



dark gray to brown, chunky, shale that exhibits a characteristic resistivity diagram on electric logs. Along the northern shelf area, the Meramec is divisible into four limestone members that are light colored, medium to finely crystalline, locally oolitic, and the lower member often carries biohermal masses. This lower member produces oil and gas in Roberts County, Texas.

The Chester series, above the Meramec, consists of coarsely crystalline shallow water limestones that are often oolitic, interbedded with gray-green shales. Near the base is a sandstone that is locally extremely calcareous, often quite argillaceous, and it may be a sandy dolomite. Most of the calcareous material, whether parent rock or cementing material, is usually oolitic and oolicastic, giving the rock a degree of porosity. This is the "Manning zone," the reservoir rock for the Ringwood Pool in Major County. Fig. 4 above shows location of the pools in northwestern Oklahoma.

According to Fig. 5, Chester rocks extend well across the area, except on the northeast where they wedge out.

Wheeler (1951) has pointed out that the rocks of the Meramec and Chester series seem to grade southward, basinward, into the argillaceous facies of the Mississippian, or the Caney-Mayes formations "whose equivalence is in some doubt."

Conformably upon the Caney shale, which carries upper Mississippian fossils, is the Springer shale of Pennsylvanian age. The only difference between these two shales is a minute change in color: From the dark brown to black, chunky Caney shale to the dark gray, more or less fissile and brittle Springer shale. One of the best methods of differentiating between these two shales is on the electric log. The Caney shale exhibits a minimum self-potential value with an increase in resistivity values, while the Springer shale shows low self-potential and low resistivity values, and it often carries sand bodies.

It is in these sand bodies that the Springer production is found in the southern area. Fig. 5 shows the northward limit of the Springer where it is overlapped by the Morrow rocks.

Overlying the Springer is one of the most controversial series in the entire Anadarko Basin, and there is little unanimity of opinion as to correlations in the pre-Des Moines Pennsylvanian rocks. According to Hudson (1949), beds assigned to the Atoka are the youngest in the area of study to disappear by reason of onlap, and all post-Atoka Pennsylvanian rocks are present throughout the entire area.

Atoka rocks are dark limestones that are often very hard and may be sandy enough to give the rock a glassy appearance. There are occasional beds that carry green grains. Interbedded with the limestones are dark gray to black, micaceous shales that carry minor amounts of sand. When traced toward the north and west, into Beaver County and southern Kansas, the Atoka rocks are predominantly dark shale with some dark colored cherty limestones.

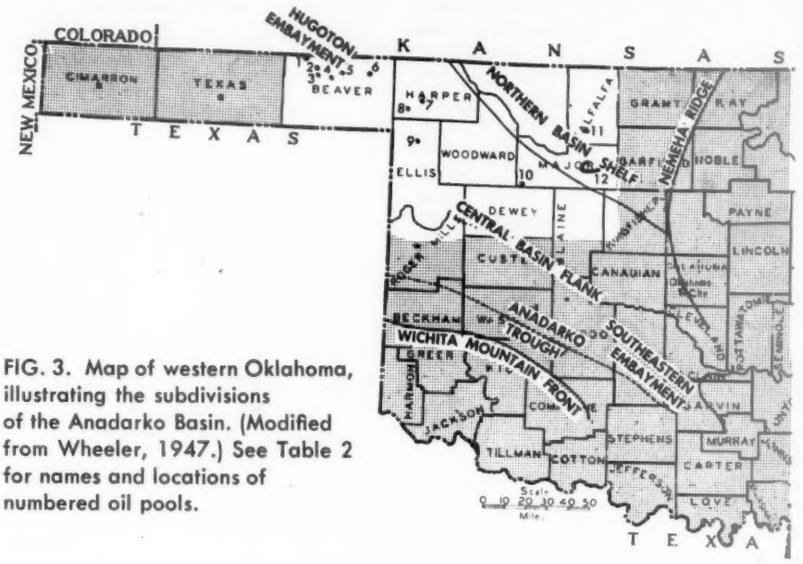


FIG. 3. Map of western Oklahoma, illustrating the subdivisions of the Anadarko Basin. (Modified from Wheeler, 1947.) See Table 2 for names and locations of numbered oil pools.

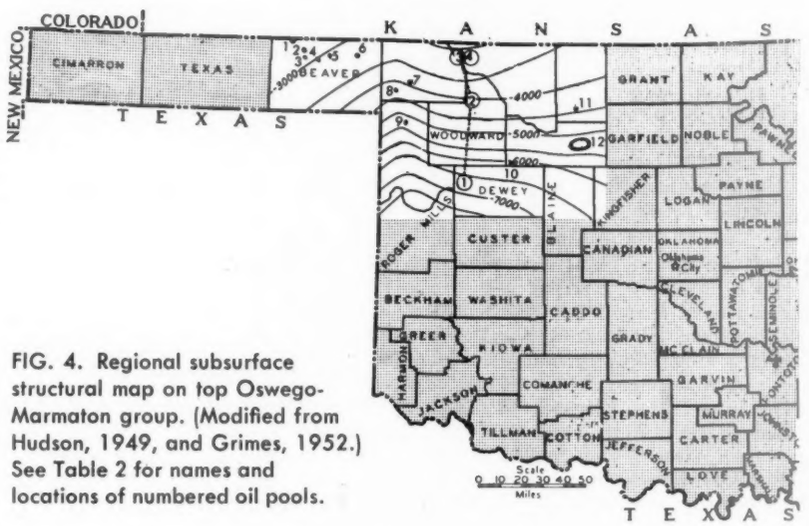


FIG. 4. Regional subsurface structural map on top Oswego-Marmaton group. (Modified from Hudson, 1949, and Grimes, 1952.) See Table 2 for names and locations of numbered oil pools.

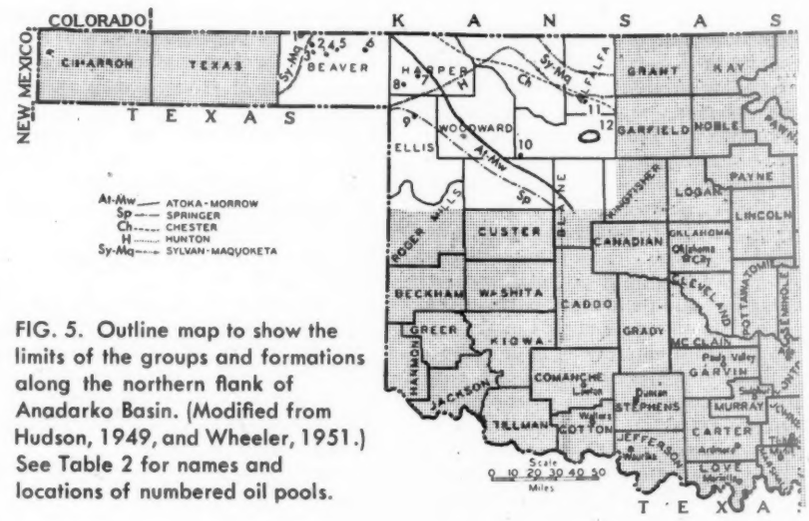


FIG. 5. Outline map to show the limits of the groups and formations along the northern flank of Anadarko Basin. (Modified from Hudson, 1949, and Wheeler, 1951.) See Table 2 for names and locations of numbered oil pools.

Anadarko Basin

The nature of the Atoka-Morrow contact is not clear along the northern shelf of the Anadarko Basin. Wheeler (1951) pointed out that the first true mountain building movement commenced along the axis of the southern Oklahoma basin in late Morrow time, such that the basal Atoka conglomerates overlap all rocks from Morrow down to Viola and Simpson. Both the Oklahoma City, Pauls Valley-Lindsay arch, and the chief uplift in the area east of Seminole, occurred during this epoch, that is, post-lower Dornick Hills, pre-upper Dornick Hills. Near the town of Moore, Oklahoma, Wheeler has described the Moore formation as being Atoka in age and resting on the Springer, Caney, Mayes, and Woodford formations, respectively.

In the deep Superior No. 51-11 Weller, sec. 11, T. 8 N., R. 12 W., a fairly complete section of Atoka rests on a thick Morrow sequence (Wheeler, 1951), which is what would be expected in the deeper parts of the basin where there was essentially continuous deposition throughout the entire Pennsylvanian era.

The Morrow rocks are quite similar to the Atoka rocks, being dark colored, argillaceous, and locally very sandy. Beds carrying green grains (glauconite?) are common. Interbedded with the limestones are hard dark chunky shales that may carry some sands. In Beaver County there is a lenticular quartzitic, fine to medium grained glauconitic (?) sandstone at the base of the Morrow commonly termed the "Morrow sand," which is a producing zone in southwestern Kansas.

Inasmuch as there is no descernible break between the Morrow and Atoka formations along the northern flank of the Anadarko Basin, it is postulated that there was no pronounced uplift but that sedimentation could have proceeded on a reduced scale, possibly with minor interruptions between the two epochs. This would call for a peculiar set of conditions in which the sea level and depth of water remained very near equilibrium for a long period of time to account for the minimum amount of deposition.

Based on lithology and on electrical characteristics, the Atoka and Morrow rocks are quite similar, and fusulinids are not always diagnostic in effecting a subdivision. Maher and Collins (1949) found thick sections of both Atoka and Morrow strata in the Hugoton embayment in southwestern Kansas, but did not establish a definite boundary between the two. Some workers point out definite correlations for the Morrow from the deeper parts of the Anadarko Basin into Beaver County.

Two possibilities appear to be in order. Either the Morrow rocks are confined to the deeper parts of the basin and do not extend as far north and west as do the Atoka rocks, in which case, the questionable sequence would be Atoka in age. Or, should the Morrow sequence be definitely established in the northern part of the area, beyond the limits of the Atoka rocks, it would indicate that the southwestern Kansas area remained topographically high during Atoka time. Thus the Atoka rocks have disappeared against the Morrow rocks by marine onlap, and rocks of Cherokee age rest on Morrow strata. In Fig. 5, the up-dip limit of the Atoka-Morrow rocks is shown.

Estimated Proved Reserves in Producing Areas of the Anadarko Basin*

Compiled by Claude V. Barrow, Oil Editor, The Daily Oklahoman

Field or area	Oil and condensate, million barrels	Natural gas, billion cubic feet
Elk City, Okla.	100	516
Ringwood, Okla.	15	110
Golden Trend, Okla.	220	1,150
Carter-Knox, Okla.	2	13
Chitwood, Okla.	15	160
Cement, Okla.	125	.....
East Cement	.....	52 (Sweet gas)
West Cement	.....	74 (Sweet and very wet gas)
Apache, Okla.	50	†
Beaver County, Okla.	4	Unknown
Light field	1	6
Washita-Kiowa counties	2	Unknown
Chickasha, Okla.	(dry gas)	136
Roberts County, Texas	50-75‡	Unknown
Hugoton field: (dry gas)		
Kansas sector		12,800
Oklahoma sector		6,400
Texas sector		5,900
		25,100
Liberal, Kansas		29
McKinney, Kansas		60

‡This includes scattered fields in Texas panhandle area.

†Gas reserves substantial but not available.

*These data are based on proved reserve estimates of companies that operate in the area. Oil reserves of the Anadarko Basin could be increased somewhat if some of the so-called southern Oklahoma fields were included. It is difficult, however, to define geologically the basin in this particular area.

Above the Atoka rocks, the complete sequence of Pennsylvanian and Permian rocks are found to extend across the entire area of study, except where the younger beds are missing on the surface outcrops to the east. This entire sequence may be said to be the "blanket-type" deposits. Thus any oil to be found in these beds would of necessity be largely dependent upon structural uplift rather than stratigraphic wedge edges. There are wedge edges of porosity to be found, however, in the Lansing-Kansas City and in the Marmaton and Cherokee groups. In these cases there has been no interruption of deposition, but the traps have been formed by changes in facies, from limestones or sandstones to shale.

Lower middle Pennsylvanian, the Des Moines series, is represented by the Marmaton and Cherokee groups. These rocks thin from southwest to northeast by reason of marine onlap upon the Atoka-Morrow surface which underlies

Area of Promise

them. These rocks consist of dark gray to black, silty, micaceous and chunky shales with subordinate impure shaly sandstones and limestones. Toward the northeast there is a facies change such that the shales are in part replaced by limestones, making exact bed-for-bed correlations difficult.

In the eastern and southern portions of the area under study, the Cherokee often carries well developed sandstones, commonly near the base, but rarely near the top. These are referred to as the Prue sandstone at top (recognized in Alfalfa County), and the Bartlesville sandstone that may be locally well enough developed to carry oil.

The Marmaton group includes the "Big Lime" and the Oswego. Taken as a whole, this group is made up of thick limestone units with subordinate thin shale interbeds. In Beaver County, this group averages approximately 300 ft thick, and is made up of light colored coarsely crystalline limestones that are abundantly fossiliferous, often oolitic and cherty, and may be slightly dolomitic. These limestones are indicative of shallow water deposition. Porous zones are found indiscriminately throughout the limestones, and may be described as a vuggy, intercrystalline, intergranular, and some solution or cavernous types of porosity. The shales are gray to dark gary.

This group also exhibits a well-developed facies change from a predominantly basinward shale facies containing impure limestones, to a shelf or platform environment that is made up of clean limestones with minor amounts of shale. This fact of the facies change, from shaly phases up-dip into porous clean limestones, may be largely responsible for the pooling of oil in Beaver County.

Ingalls (1951) has postulated reef-building conditions along the northern flank of the Anadarko basin starting possibly in Marmaton times and extending up into the Missouri series. A Marmaton reef is said to produce the oil in the Novinger Pool northeast of Liberal, Kansas, and the equivalent beds in Beaver County closely resemble the rocks of that "reef." Further study will be necessary to definitely establish the existence of a Marmaton reef extending into Beaver County.

Following the shallow water conditions during the Marmaton, the rocks of the Missouri series indicate continuing shallow water conditions with a slight deepening of the seas. The multitudinous surface subdivisions of this series are not differentiated either in well cuttings or on electric logs, so it is common practice to pick the easily determined top of the Lansing, and to in turn combine the Lansing with the underlying Kansas City limestone, and consider the Lansing-Kansas City as making up the entire Missouri series.

Rocks of the Lansing-Kansas City are tan to buff limestones that range from coarse to fine, are usually fossiliferous, and are often cherty. There are many persistent thin dark gray, carbonaceous shale interbeds in the northern part of the area that increase in prominence

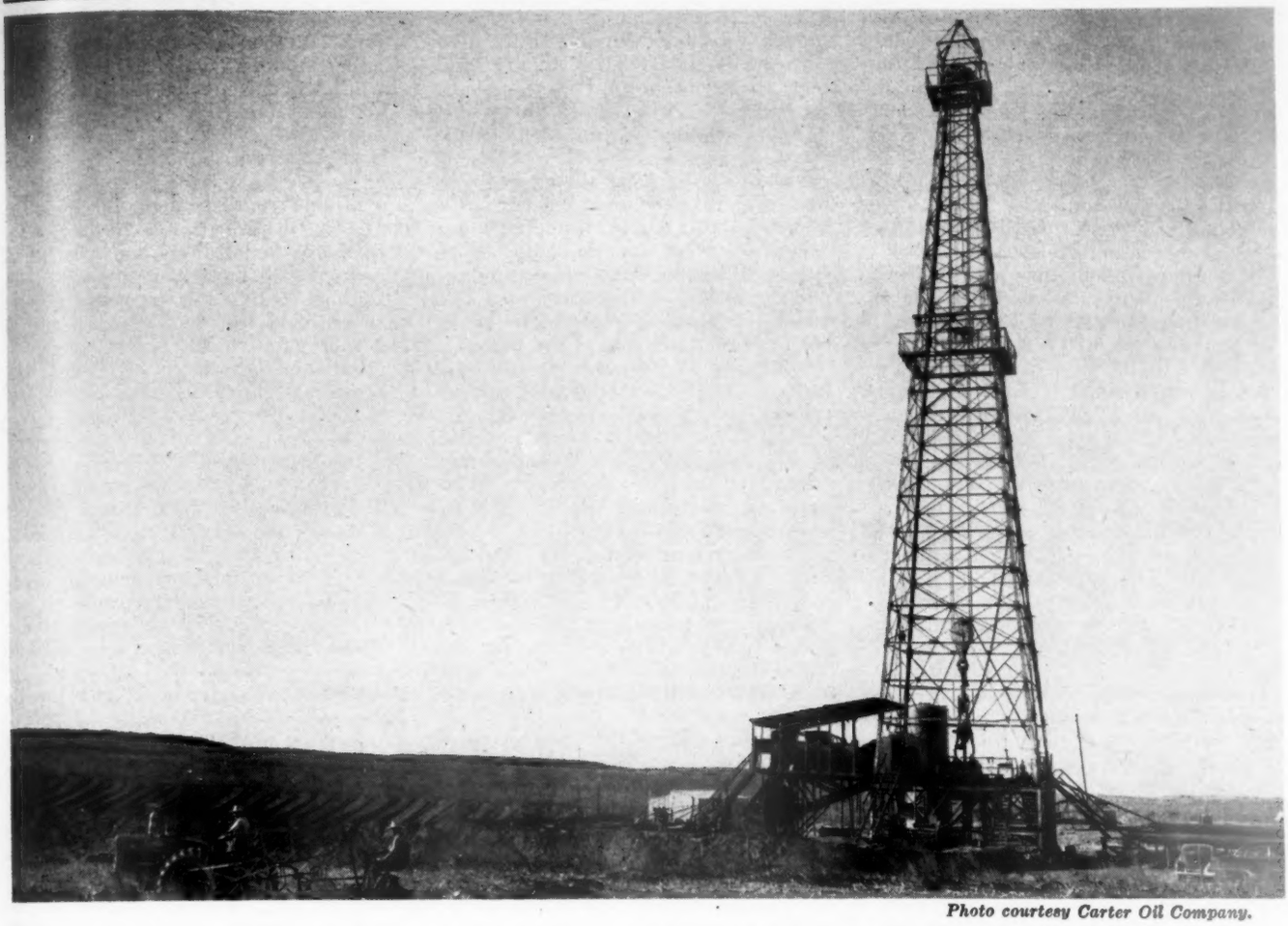


Photo courtesy Carter Oil Company.

Carter's No. 1 Myron J. Phillips, productive wildcat near Sharon in Western Oklahoma. In the foreground, Mrs. Phillips, driving the tractor, helps her husband, on the binder, harvest their kaffir corn which was stunted by the drouth which grips Oklahoma.

rather abruptly as this group is traced basinward.

Many geologists refer to the limestones of the Lansing-Kansas City as being reef-like in that they are fossiliferous, often clastic, and they exhibit a high degree of porosity. So far there is no unaniminity of opinion as to whether this thick section of porous limestones should be called a reef build-up or not.

Above the Missouri series is the Virgil, uppermost Pennsylvanian, consisting of a cyclic succession of marine and non-marine deposits. Subsurface correlations are generally good, but few attempts have been made to pick out the many cyclic members and use these successions in correlations. Limestones in the Virgil are light, medium, to coarsely crystalline, and fossiliferous; while the interbedded shales are gray and are usually fossiliferous.

Permian rocks are divisible into the Guadalupe, Leonard, and Wolfcamp series, in descending order. The upper two are the red bed series consisting of interbedded red sands and sandy red shales, with few gypsum and anhydrite members, while the Wolfcamp is largely marine and can be differentiated into groups.

The Wolfcamp series carries the Chase group or "lower Permian limestones" that are so well known in southwestern Kansas. Until recently these limestones were hardly noticed in Oklahoma for several reasons:

1. Casing was often set through these limestones, so no samples were saved, and no electric log was run through this sequence.

2. Samples, when caught, were usually poor in the upper part of the hole because of the tendency to "make hole" fast near the top, and because the rig had seldom "mudded up" at this shallow depth.

3. The geologist was seldom called out on the rig at this shallow depth because he was to "look at" the lower horizons and possible pay levels.

The Chase group produces the gas in the Hugoton gas field, and is thus one of the most important gas horizons in the world. Limestones of the Chase may be followed eastward along the northern flank of the Anadarko Basin to approximately the eastern limit of this study, where the limestones seem to grade laterally into shales. Although this lateral gradation probably has very little bearing on the oil and/or gas possibilities of these rocks, it does have some bearing on the basin position of deposition of the limestones.

Geologic History

The geologic history of the northern flank of the Anadarko Basin is directly related to the development of the basin. Heretofore a great majority of exploration has been based on surface geology and subsurface geology as deduced from geophysical data. It is proposed here that a clear understanding of the basin history is an important exploration method that has not been fully exploited as yet.

Throughout the Paleozoic, from Cambrian into early Pennsylvanian, the southern trough area of the Anadarko Basin (the borderland) subsided more or less steadily such that sediments of each period reached a maximum thickness. This may be seen in the maximum of some 6000 ft of Arbuckle, over 2700 ft for the Simpson (Decker and Merritt, 1931), and 1000 ft for Hunton rocks. There are few unconformities and many of these are believed to disappear into the basin where deposition was continuous.

In contrast, the northern flank tended to remain essentially positive, during the same period of time. Each system of rocks therefore is to be found in a minimum development. As a result, important unconformities were developed along the northern flank which are significant in the stratigraphic pooling of oil and gas.

Clastic deposition in the Arbuckle dolomite, the oldest sedimentary formation in the area, is very minor and is confined to a few thin sandy dolomite beds. The thick section of Arbuckle dolomite was deposited in uniform

warm shallow marine waters in which the southern flank (borderland) subsided uniformly, while along the northern flank (foreland) the Arbuckle is thinner, indicating less subsidence but nonetheless equivalent conditions. The Arbuckle seas covered the entire Anadarko Basin area, extending as far westward as the Las Animas arch, and to an unknown distance toward the north beyond the basin (Hintze, 1951).

The Simpson, too, thins progressively northward onto the northern flank where it is thin and poorly developed. In Superior No. 81-17 Norris, sec. 17, T. 19 N., R. 10 W., it is 650 ft thick; in Continental No. 1 F. E. Benton, sec. 2, T. 25 N., R. 22 W., 400 ft thick and contains a minimum amount of sand. There are less than 100 ft of Simpson in the wells in eastern Beaver County.

The clean sandstones, coarse to very finely crystalline limestones and green shales of the Simpson group indicate a shallow shelf environment. It seems that the southern basin area was subsiding in order to receive the thick Simpson sediments, while the northern flank subsided very little and received a minimum thickness of sediments. On the basis of regional studies, it is believed that the Simpson of the northern flank is upper Simpson age. During the deposition of the lower and middle Simpson in the southern area, the northern flank was either undergoing erosion, or was receiving very little if any sediments. While during the upper Simpson, the seas spread far and wide over a wide area and transgressed upon the Arbuckle rocks along the northern flank.

In the eastern part of the northern flank area, and far to the west beyond Beaver County, the Viola limestone is a normal shelf deposit of buff, medium to coarsely crystalline limestone. In Beaver and Harper counties, however, the Viola appears to be a basinward facies of very silty limestones interbedded with minor amounts of dark shales.

Along the eastern part of the northern flank, the Viola has been removed by erosion and the Woodford shale rests on Simpson rocks.

The Sylvan shale is typically a fairly deep water deposit, thickening somewhat basinward, indicating uniform conditions over the entire basin area. (Fig. 5.) Along the northern flank, however, the Sylvan is locally dolomitic, and when traced on northward and westward, the increase in dolomitization is known as the Maquoketa dolomites of southern Kansas.

Silurian and Devonian eras are represented by the Hunton terrane. These rocks are confined almost entirely to the deeper parts of the basin and do not extend very far to the north. Fig. 5 illustrates the wedge edge of the Hunton rocks along the northern flank.

Following the deposition of the Hunton there was an uplift over much of the Anadarko Basin area, which was quite pronounced along the northern flank. This uplift and subsequent erosion bevelled the Hunton, Sylvan and Viola formations down to an essentially flat surface, as seen by the fact that the lower Mississippian rocks do not show any regional thinning in the area.

Lower Mississippian, Kinderhook rocks, vary from hard brown shales typified by the Woodford in the eastern part of the area, to brown, dolomitic, silty, impure limestones with minor amounts of green-gray shales in the far western part of the area. Farther north, rocks assigned to the Kinderhook are coarsely crystalline dolomitic limestones. Hence the direction of the shore line from the present subcrop area is in doubt — probably it lay along the southern or borderland side of the basin.

Following the Kinderhook, the seas carried a high concentration of calcium carbonate in the Hugoton embayment during the middle Mississippian. Rocks of this age are gray to buff, finely crystalline siliceous limestones. Basinward, or southward, these limestones become more silty.

The Meramec rocks are predominantly limestone. According to Maher and Collins (1949), these thin from the bottom due to onlap from the basin area upon the northern flank, and at the top due to erosion. Fossil content indicates clear warm shallow water deposition.

Beginning with the Chester, there was a marked change in the lithology of the Mississippian rocks, and these rocks do not completely cover the area being studied. See Fig. 5. When correlated with the Caney shale to the south, in the basin area proper, the clastic material would indicate some minor uplifts along the northern flank.

At the close of the Mississippian epoch there was a slight uplift along the northern flank of the Anadarko Basin which caused the seas to withdraw into the deeper parts of the basin.

Wheeler (1947) pointed out that there is a complete sequence of deposition in the deeper parts of the basin such that the Caney shale equivalents grade upward into the uppermost Mississippian, and there is uninterrupted deposition on into the Pennsylvanian. On the northern flank, however, this minor post-Mississippian uplift prevented the Springer seas from extending as far north as Harper and Woods counties. See Fig. 5.

The lower Dornick Hills, Morrow rocks, followed the Springer without significant interruption. In this case, however, the Morrow rocks spread farther northward: into the Texas Panhandle, into southeastern Beaver County, and into the northern counties of Oklahoma.

To the south, in the Ardmore area, there are coarse conglomerates in the upper Dornick Hills, indicative of a pronounced uplift between the lower Dornick Hills and the upper Dornick Hills, now called the Dornick Hills uplift.*

The ensuing deposition during the upper Dornick Hills, or Atoka, spread far and wide in the Anadarko and Ardmore basins, as well as in the McAlester Basin. In these areas the Atoka beds rest uncomfortably first upon Morrow rocks, then on Springer, and finally on upper Mississippian rocks. It is in these basal Atoka sands that one of the major oil possibilities is to be found along the northern flank of the Anadarko Basin. See Fig. 5 for the wedge edge of the Atoka-Morrow rocks.

Middle Pennsylvanian, Deese or Des Moines, deposits spread over most of Okahoma and Kansas and covered all rocks, which had been exposed by the Dornick Hills orogeny. For example, Deese rocks rest on Atoka beds in the deeper parts of the basin; on middle Mississippian rocks in northern Oklahoma; and on eroded Ordovician rocks on the uplifts where these were exposed to erosion by the Dornick Hills orogeny.

Deese deposition is characterized by distant sources of sediments, quiet, blanket-type deposition spreading over a large area. Along the northern flank of the basin there is a greater percentage of limestone and sandstone when compared with shale, because of the self environment of deposition. Limestones are usually normal marine, semidense types while the sandstones are well bedded, quartzose, and usually porous.

Hoxbar, or Missouri, rocks are mostly limestones and shales along the northern shelf area. These sediments are also widespread, mostly blanket-type deposits, with some stratigraphic wedges being developed where the limestones change to shales.

Quiet depositional conditions prevailed throughout the Permian along the northern flank of the basin. Sediments change from predominantly marine limestones and shales upward into typically non-marine red bed deposition.

Structure

Regional. Throughout the northern flank of the Anadarko Basin the rocks exhibit a monoclinal dip southward of less than one degree. Small local structures are seldom apparent because of the great distances between wells and because of the lack of close control.

Fig. 4, regional structure on top of Oswego-Marmaton, shows a monoclinal southward dip. From a sub-sea depth of —3000 ft along the Oklahoma-Kansas line, it dips below —7000 ft along the southern edge of the area under study, which is approximately 50 ft per mile. A smaller contour interval will show minor structures but no major uplifts are indicated. It is significant to show, however, the regional flattening of the dip along the Oklahoma-Kansas line while the dips on the map below —3500 ft show an abrupt increase.

A regional synclinal area is shown extending in a general north-south line just east of the Texas line. This is evidently a local deep area that leads into the basin proper.

Stratigraphic Wedge Edges

(See Fig. 5)

It is along the northern flank of the Anadarko Basin that stratigraphic trap possibilities are to be found. During the many periods of sedimentation

*This uplift has been erroneously referred to as the well known post-Mississippian pre-Pennsylvanian uplift of central Oklahoma.

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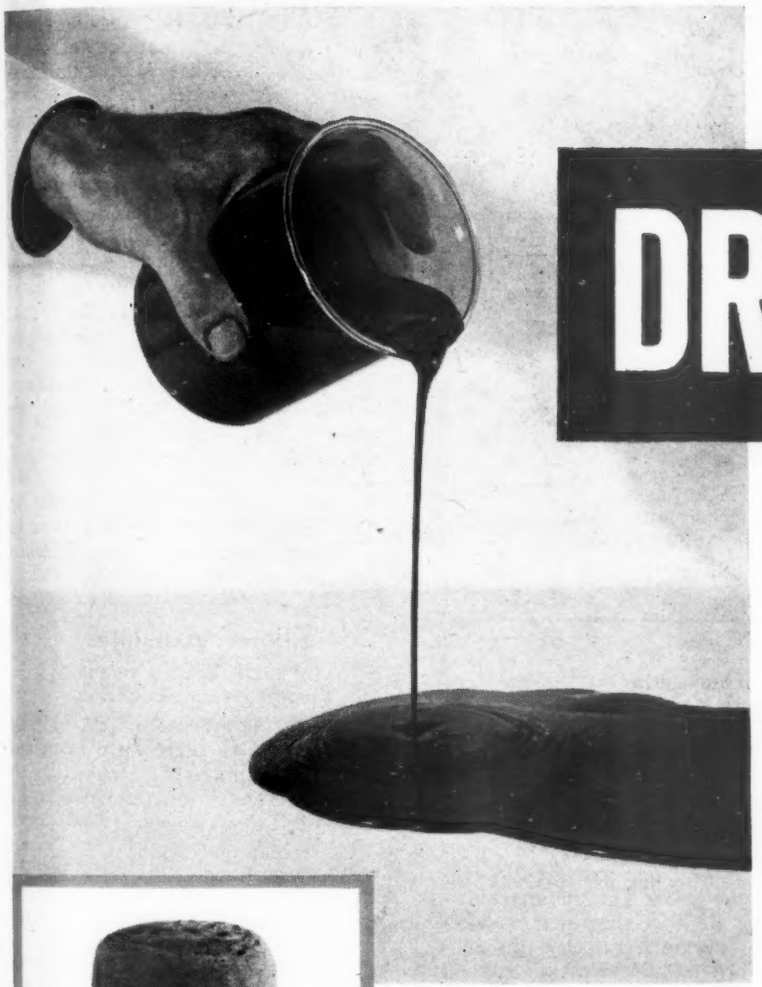

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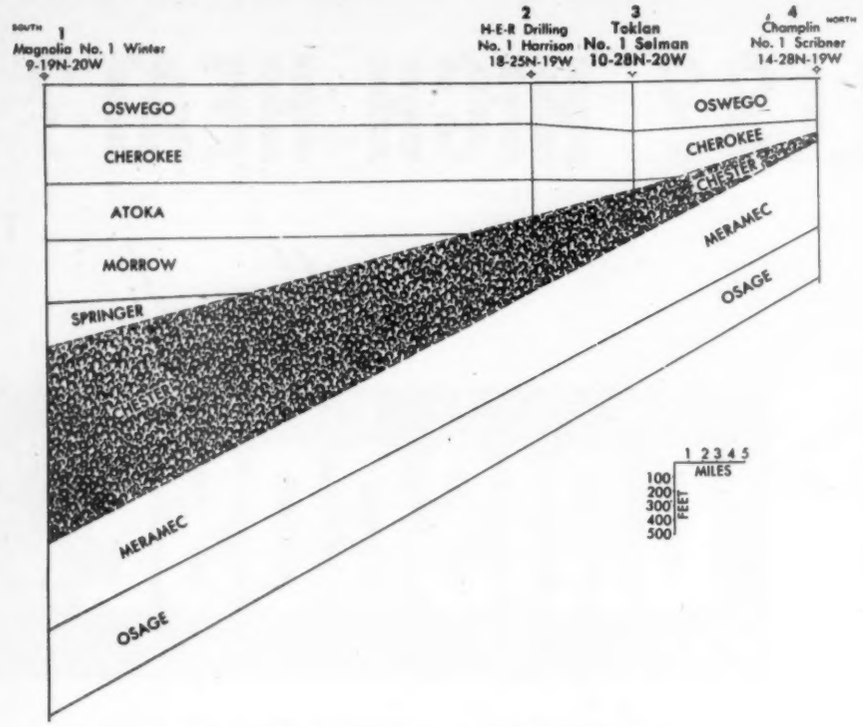

FIG. 6. Regional north-south cross section along northern flank of Anadarko Basin. (Modified from Hudson, 1949.) Fig. 4 shows the location of the wells used in the section.

within the basin and along the flanks, some formations were confined wholly to the basin proper while other were deposited in the basin and extended up out of the basin onto the flanks. In the latter case, basinward facies of the formations are to be correlated with the equivalent shelf or platform deposits.

The Arbuckle and Simpson groups, and the Viola limestone, extend completely across the area from the basin into Kansas. The wedge edge of the Viola is located in the extreme western part of the Oklahoma panhandle (Wheeler, 1951).

The Sylvan-Maquoketa formation is confined largely to the basin and is found to wedge out in a northward extending pattern, yet it covers practically the entire area under study. The Hunton follows much the same pattern as does the Sylvan-Maquoketa except it is limited to an even smaller area in the basin.

Within the Mississippian, the Meramec-Osage rocks extend across the area. During this interval, the chief site of deposition in the basin evidently moved westward because the east and northeast edge of deposition of the Chester is found in a northwest-southeast line along the east edge of the area. This line marks the farthest limit of Chester rocks and shows where middle Pennsylvanian rocks rest on Chester and then on Meramec rocks.

Lowermost Pennsylvanian, Springer, is confined to the basin and did not extend out of the basin. The line marking the northern limit of the Springer extends across northern Ellis, southwestern Woodward and Dewey counties.

The Atoka-Morrow limit is shown to lie northeast of the Springer wedge. North and east of this line the Des Moines rocks rest first on the Chester rocks and then on Meramec-Osage rocks.

It is the position and alignment of these upper Mississippian and lower Pennsylvanian formation wedges that largely govern the existence of the stratigraphic traps in northwestern Oklahoma. From each new well that is drilled in this area, new data are collected for determining more accurately the exact position of these wedges.

In addition to these wedge edges of formations, it is possible to pick out smaller pinch outs of individual porous members and zones within these formations. For example, the "Manning zone" of the Chester; the "Morrow sand" and the irregular sand bodies in the Cherokee group.

Following the Atoka, all middle and upper Pennsylvanian and Permian rocks were deposited across the entire area and are not involved in the wedge edges as developed in the lower beds. It is possible, however, to find local porosity wedges in formations and zones of the upper beds, as in the Lansing-Kansas City limestones.

Cross Section. Regional north-south cross section, Fig. 6, extends from T. 19 N., R. 20 W., to T. 28 N., R. 19 W., and illustrates the manner in which the upper Mississippian and lower Pennsylvanian formations are cut out either by overlap or by erosion, and therefore how they can serve as potential traps for stratigraphic oil. In T. 19 N., R. 20 W., there is a fairly complete section from the Oswego through the Cherokee, Atoka, Morrow, Springer, Chester, Meramec, and Osage sequences. Proceeding northward to T. 25 N., R. 19 W., the Springer and Morrow rocks have disappeared such that Atoka rocks rest on thinned Chester rocks. By T. 28 N., R. 19 W., the Atoka has in turn disappeared, and the Cherokee shales rest on the wedge edge of the Chester.

Future Possibilities

See Table 2, Oil Pools in Northwestern Oklahoma

According to Wheeler (1951) any province in which there have been numerous interruptions in deposition to create convergence should have favorable possibilities for oil. These possibilities can be worked out as stratigraphic data are made available. At the present time most of the future possibilities for stratigraphic trap oil are contained within these wedging formations and groups of formations.

Permian Limestones. These limestones, belonging to the Chase group, are well developed in the western part of the area under study. They are light in color, coarse to finely crystalline, and carry many porous zones. Some porosity seems to be developed in dolomitic phases of the limestones. Minor amounts of green and gray-green shale are interbedded in the limestones. It is common to lose circulation while drilling this group of limestones.

Many wells in northwestern Oklahoma have encountered shows of oil in these limestones, but so far all drill stem tests have yielded water with traces to shows of oil. With continuing development along the northern flank of the basin, it may be possible to localize porosity zones in these limestones in which commercial production may be expected. Such production would, however, be secondary and would not be a principal objective for drilling a well.

Lansing - Kansas City Limestones. Throughout much of western Kansas

TABLE 2. Location of oil pools in Northwestern Oklahoma.

1. Light pool	T. 6 N., R. 21 ECM	5 wells in Oklahoma
2. Greenough pool	T. 5, 6 N., R. 22 ECM	3 wells
3. Floris pool	T. 5 N., R. 22 ECM	1 well
4. Beaver-Panhandle pool	T. 5 N., R. 23 ECM	1 well
5. Southwest Mocane pool	T. 5 N., R. 24 ECM	1 well
6. Northwest Knowles pool	T. 5 N., R. 26 ECM	1 well
7. West and South Stockholm pools	T. 26 N., R. 24 W	2 wells
8. South and Southeast Laverne pools	T. 25 N., R. 25 W	2 wells
9. South Salon pool	T. 23 N., R. 24 W	1 shut-in gas distillate well
10. Northeast Seiling pool	T. 20 N., R. 16 W.	1 distillate well
11. North McWillie pool	T. 24 N., R. 11 W	1 well
12. Ringwood pool	T. 21, 22 N., R. 10, 11 W	Over 50 wells

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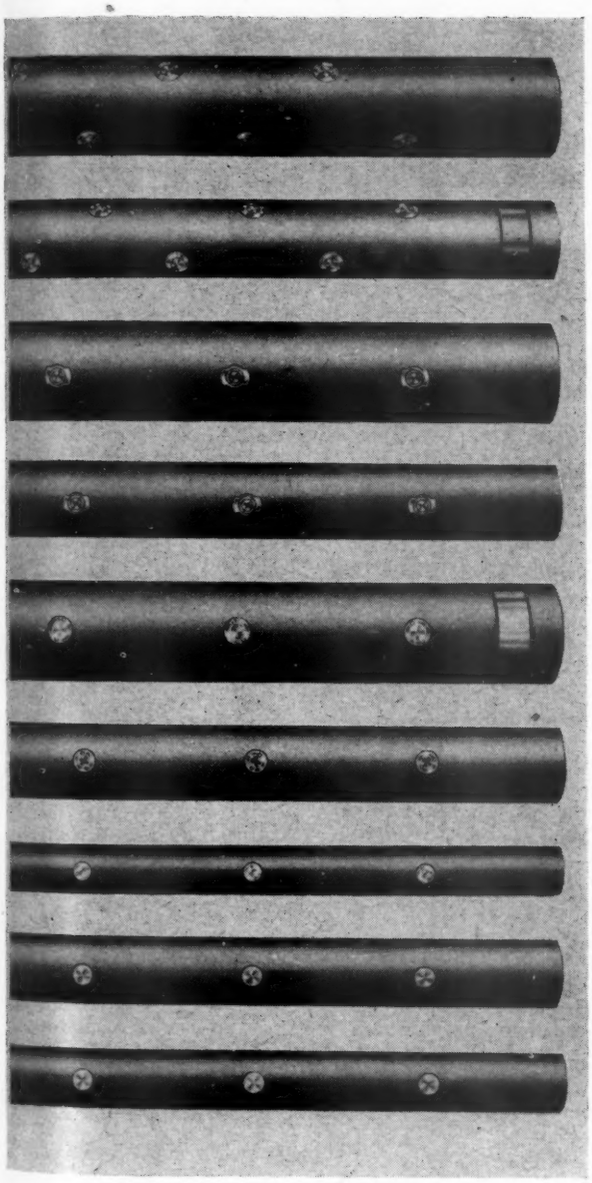

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these limestones produce oil where there is sufficient porosity and where the structural conditions are favorable. When traced southward into the deeper parts of the Anadarko Basin, the limestones become subordinate and shales predominant in this interval. The change from shales to limestones takes place rather abruptly along a line paralleling the rim of the basin.

Ingalls (1951) pointed out that ideal reef-building conditions prevailed along the southern edge of the shelf area, and that possibly a reef started to develop in the Marmaton and extended on into the Lansing-Kansas City.

Cross sections through Beaver County show the preponderance of limestone in the northwestern part of the county, and the reef concept might explain this prominent limestone build-up. It will be necessary to determine the nature of reef limestone, however, before establishing the existence of such limestones in Beaver County. Some of the limestones may be said to be "reefoid" or reef-like due to their coarse nature and clastic texture.

To date there has been no production obtained from the Lansing-Kansas City in northern Oklahoma. The Flynn No. 1 Schoolland, Sec. 25, T. 5 N., R. 22 ECM., showed oil and salt water on drill stem tests in several zones in this interval.

Based on previous experience, under equitable porosity and structural conditions, the Lansing-Kansas City limestones should be expected to produce oil in the areas where sufficient limestone build-up has occurred. In drilling in this area, the series of limestones should be watched carefully and tested frequently. Porosity is expected to be developed on the shelf, up out of the basin, and may be expected along a hinge line paralleling the rim of the basin. Such a porosity belt might be expected to be quite wide.

Marmaton Group. ("Big Lime" — Oswego formations) The Marmaton or Oswego limestone carries shows of oil in northwestern Oklahoma. Porosity is normally developed in the siliceous limestone of the lower part of the formation, and is leached and solution type, with granular zones where the limestone is locally dolomitic. Drill stem tests often recover free oil usually with a low bottom hole pressure, but production tests are usually disappointing.

In Alfalfa County the only oil well ever completed in the county was from the Oswego — a small marginal producer in the North McWillie pool.

Along the hinge line in Beaver County the Oswego changes from a geosynclinal type limestone which is dense, siliceous and hard, to a porous, shallow water limestone that is medium to finely crystalline, and in part clastic. With the dark marine shale interbeds in the limestones as a possible source, the Marmaton may be expected to produce where porosity conditions are found on favorable structures.

Production will also depend on the position of the hinge line, basinward from which no porosity is expected, while shelfward, near shore deposits are to be expected, with the development of porosity. The Floris and Greenough pools north of Beaver, Oklahoma, produce from the Marmaton.

Cherokee Group. Although the sands in this group are prolific producers of oil throughout much of Oklahoma, so far these have not shown much promise of being potential oil-bearing horizons. Oil in the Bartlesville and Prue sandstones depends on a combination of stratigraphic conditions with favorable structural disposition. Along the northern flank of the Anadarko Basin the Cherokee sands are generally poorly developed and at the same time they tend to be blanket-type sandstones.

Under these conditions it is necessary to have domal or anticlinal structures for production. To date there have been few such structures found that could yield oil from these formations.

Atoka Group. As pointed out in the discussion under basin history, the Atoka seas spread up and out of the basin, beyond the Morrow rocks, leaving an onlapping porous basal conglomerate and an avenue for the movement of hydrocarbons. Production can be expected from this basal member. Any uplift, even of minor proportions, will help to localize any oil on the basinward side of the uplift and could provide a site for accumulation of oil.

Basinward, these rocks become increasingly calcareous and shaly, thus the chances for commercial oil production are limited.

Morrow Group. This is the horizon that is currently being exploited for oil in Beaver County. The "Morrow sand" is to be found at the base of this interval. There is some question as to whether this horizon is Morrow or Atoka. Based on study of cross sections and basin history, these rocks could well be of Atoka age.

Oil production is being developed along the north rim of the basin at the up-dip pinch out of the unit. The sand is erratic in development, and the porosity is dependent on the nature and amount of cementing material, and is expected to be more shaly in a basinward direction.

Oil will be stratigraphic in this unit of rocks, in the eroded wedge edge of the formation. Minor folding may assist in the local accumulation and final emplacement of the oil.

Chester Group. As is the case in the lower Pennsylvanian groups, the uppermost part of the Mississippian is also confined to the deeper parts of the Anadarko Basin. The group extends a short distance northeastward from the limit of the Atoka-Morrow rocks.

Being chiefly limestone and shale, there have been very few shows of oil in the group, despite the oolitic and crinoidal phases of some of the limestones. Near the base is a sandstone that may be considered an onlapping member and as such can be expected to carry oil under advantageous conditions of structure and porosity.

Basinward, however, this basal sandstone becomes shaly and more limestones are found. Thus, here again, it is essential to select a location advantageously located along the old shore line where the basal sand is exposed along the wedge edge.

Meramec Group. Along a line extending in a northwesterly direction, north of, and beyond the wedge edge of the Chester, the limestones of the Meramec have been exposed to weathering and have been made porous. Under these conditions, these limestones may be expected to contain oil in commercial quantities. A few pools in southwestern Kansas produce from this group of rocks.

Production will be dependent upon post-Meramec, pre-Atoka, or pre-Deese uplift and erosion.

Hunton Terrane. After the discovery of oil in the eroded edges of the Bois d'Arc member of the Hunton in West Edmond pool, a concerted search along the northwestern extension of this wedge edge of porosity has failed to produce any oil. Either the Hunton is too deep, or the porous phases of the Hunton are below the water level. This horizon can not be considered more than a poor prospect.

Pre-Hunton Possibilities. At the present time the Pre-Hunton rocks are not considered as possible producing horizons. The Simpson thins northward across the basin and in the area of study is less than 500 feet thick. In Continental No. 1 Benton, Sec. 2, T. 25 N., R. 22 W., it is 400 ft thick, and does not contain any good sand bodies.

As is observed in Arbuckle production, it is necessary to uplift the Arbuckle limestone, erode it to make it porous and then cover it with a dark shale, in order to achieve production. Sizable uplift is necessitated in this concept for Arbuckle production, which uplift has neither been found, nor is it expected to be found in the area of study.

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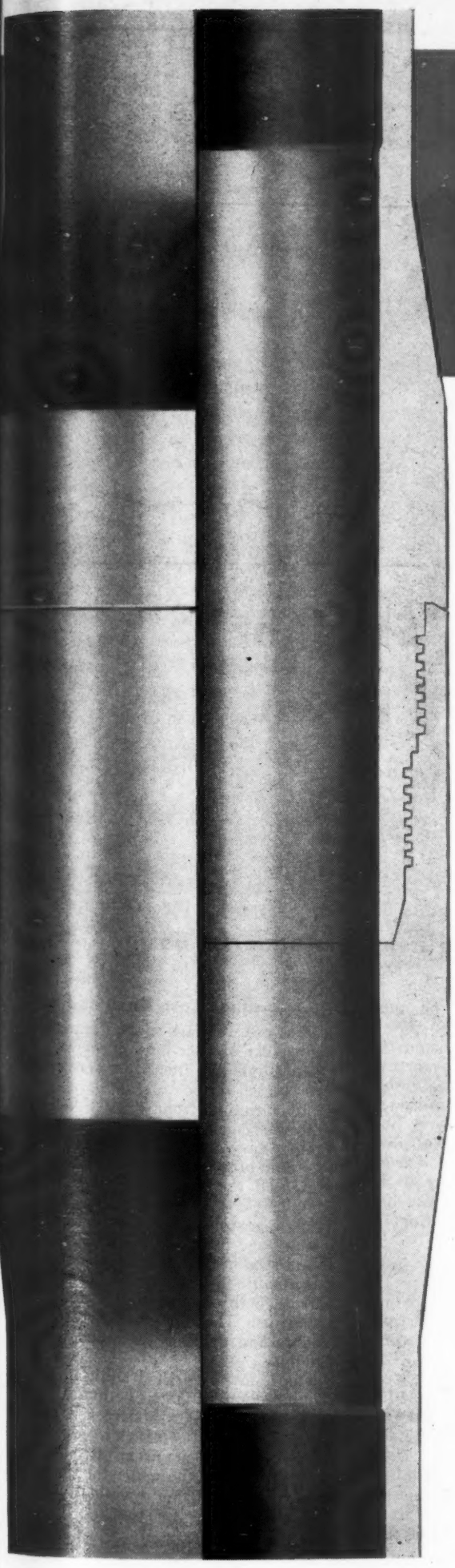

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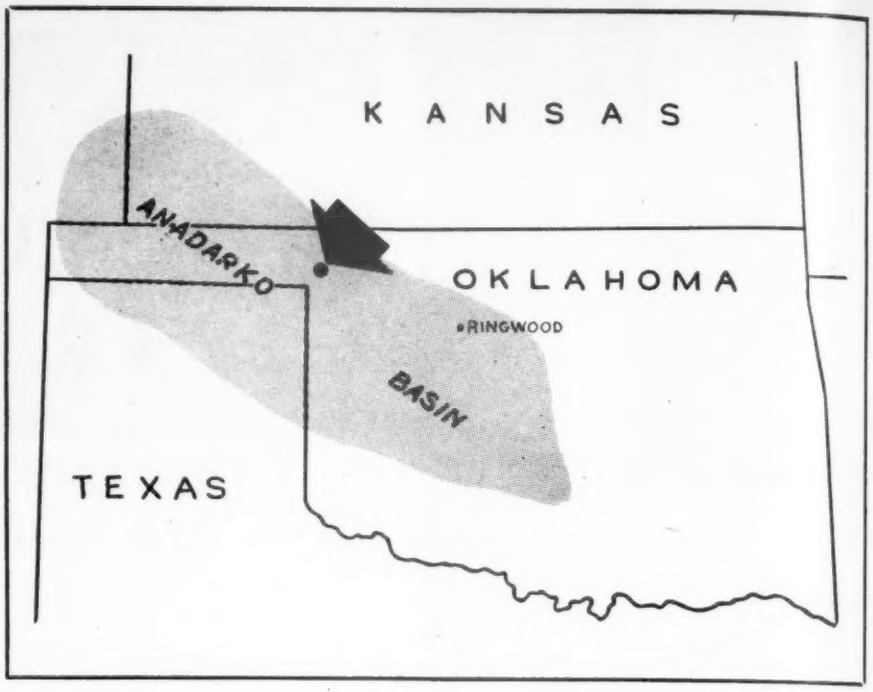
Sunray's No. 1 E. M. Wolf on the north rim of the vast Anadarko Basin in Oklahoma.



Straight Down to Pay†

Sunray discovers significant gas-distillate field in Anadarko Basin

A SIGNIFICANT gas-distillate discovery was made recently in western Oklahoma by Sunray Oil Corporation. The strike is on a block of 15,000 acres assembled by Sunray on a geophysical prospect, located on the north rim of the vast Anadarko Basin shown in the drawing.

On Regional Trend

The discovery is important in that it lies along a regional exploration trend which has commanded Mid-Continent attention for the past several years. Since 1945 a highly-competitive geophysical and leasing play has been in progress on this trend in search for oil fields in the Pennsylvanian and Mississippian formations.

Back in 1945, the Ringwood field was discovered at point "A" on the map; subsequent drilling later proved an area which will ultimately produce 60,000,000 bbl of oil from an ultimate area of 40,000 acres.

Since the date of discovery a series of deep tests have been drilled on prospects along a 110-mile northwest-southeast trend extending northwest of Ringwood across the Oklahoma Panhandle into southwestern Kansas.

The Sunray discovery is situated on this regional trend as shown by arrow at "B" on the map. The find followed a detailed geophysical survey with reflection seismograph. The discovery lies 42 miles southeast of the 1951 oil discovery of Flynn Oil Company in Beaver County (shown as "C" on map). It is 66 miles northwest of a recent gas-distillate discovery in Major County (shown as "D").

Gas-Distillate Well

Sunray's discovery is its 1 E. M. Wolf, located in the C NW NE/4 of Section 4-25n-25w, near LaVerne in Harper County, Oklahoma.

On initial completion the well tested 5,200,000 cu ft of gas through a 1-in. choke. From the separator, 47 bbl per day of 68.2 deg API gravity distillate was recovered.

The producing formation is the Morrow sand of lower Pennsylvanian age. This section was gun-perforated from 7190-7230 ft. Wellhead pressure initially registered 275 psig on tubing-head gage.

Conquer Lost Circulation

Porous formations in the Permian and Pennsylvanian sections threatened to create trouble for the drilling crew. Mud was lost at seven different levels from depths ranging from 3504 to 8219 ft. However, constant check on the levels of the rotary drilling fluid in the return pits and proper treatment of the mud prevented the occurrence of any real trouble.

For example when circulation was lost at 5642 ft, crews mixed 15 sacks of cotton seed hulls, along with 50 sacks of a bentonitic clay*, 50 lb of organic disperser‡, 5 lb of caustic soda and 25 lb of soda ash. The admixture corrected the trouble and drilling proceeded without difficulty.

The hole was drilled straight, under the direction of Jack Patton, veteran toolpusher for Kerr-McGee Oil Industries, Inc., the contractor. Deviation from vertical did not exceed two degrees at any point in the well; the job was finished with the hole less than one degree off vertical. * * *

†Taken from *The Sunray News.*

*Magcogel.
‡Tannathin.

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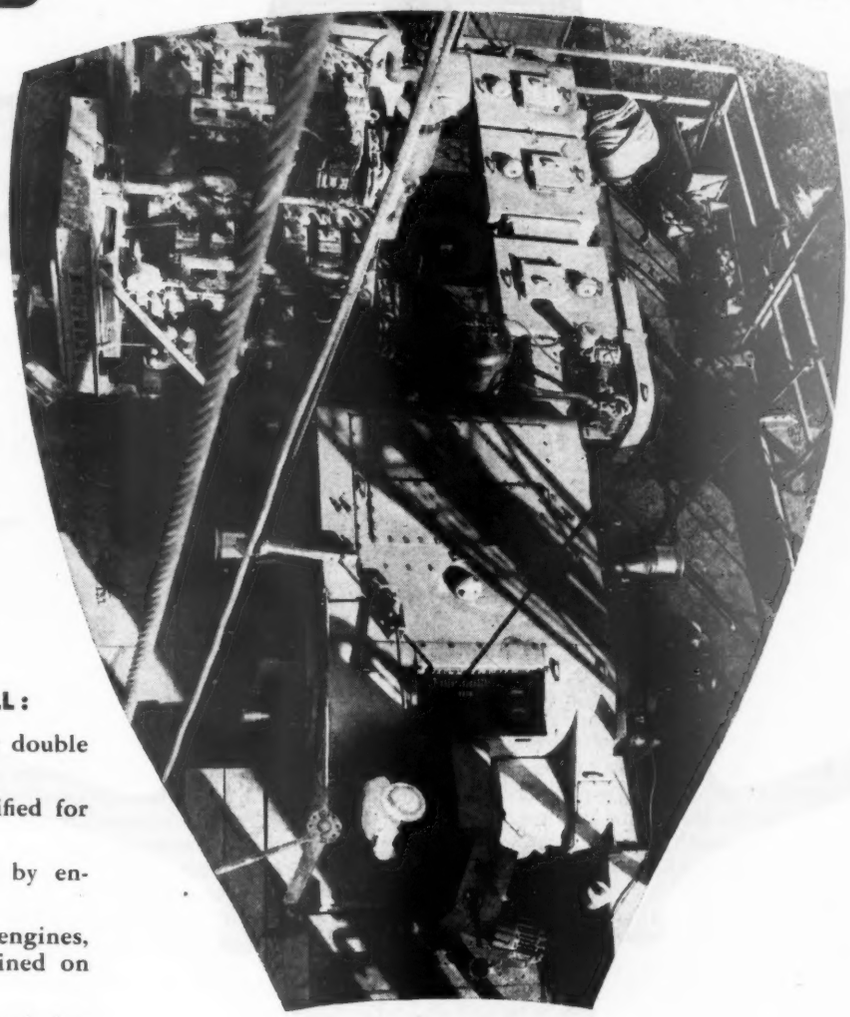

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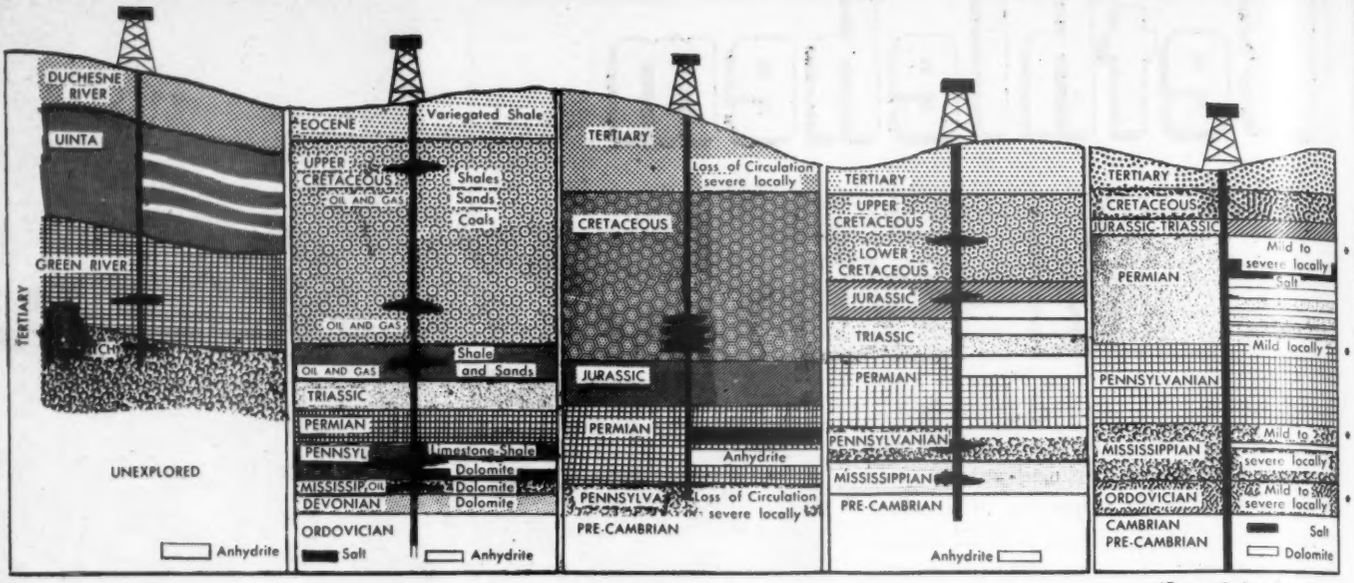

*Loss of circulation.

Uintah | San Juan | Denver-Julesburg | Powder River | Anadarko

Drilling Muds in the Anadarko Basin

Shale sections, salt and anhydrate zones, etc., in Anadarko make special design and maintenance of drilling muds essential

WARD L. PARRY, JOHN C. LUCK, JR., and GEORGE B. HANSON

THE extremely rich Anadarko Basin is a typical, sedimentary basin bordered by the Wichita Mountains and Amarillo uplift to the south; the Hugoton gas field to the west; the Central Kansas uplift to the north, and the Nemeha ridge of Oklahoma and Arbuckle Mountains to the east. The Anadarko Basin is noted for long treacherous shale sections, zones of salt and anhydrite, and combinations of high formation pressures with loss of circulation, requiring special attention in the design and maintenance of drilling muds. Almost all types of muds are used that are common to the entire Mid-Continent, West Texas, and parts of the Rocky Mountain regions.

The sedimentary rocks are mainly Palezoic in age and include formations from the Cambrian through the Permian. Formations of younger age cover most of the area but are not considered as being a source of petroleum. The deepest portion of the basin is situated near the Wichita Mountain front. For nations generally get progressively thinner and shallower to the north and west. Mud problems associated with drilling deep, thick shale sections predominate in the southeastern portions of the basin. The problems of mud contamination with salt and calcium sulphate increase as these evaporites attain maximum development, in the Permian, to the westward.

To portray typical mud designs and treatments, three areas within the basin were selected for discussion: (1) Southwestern Kansas and Oklahoma Panhandle, (2) West Central Oklahoma, and (3) South Central Oklahoma.

Southwestern Kansas and Oklahoma Panhandle

Oil and gas development in this part of the Anadarko Basin covers Clark County and the nine most southwesterly

The Authors

W. L. Parry

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Ward L. Parry is a member of Baroid's mud department as a field service engineer and has been active in servicing drilling fluids used in east central, southwestern, and western Oklahoma since 1947. He attended Iowa State College, Ames, Iowa, and graduated with a B.S. degree in 1942. Following service in the U. S. Navy from 1942 to 1946, he joined the well logging department of Baroid Sales Division.

John C. Luck, Jr., a native of Magnolia, Arkansas, received a B. S. degree in Petroleum Engineering from the University of Oklahoma in 1950. Following graduation, he joined Baroid Sales Division as a field service engineer servicing drilling muds in southern Oklahoma.

George B. Hanson was graduated from the University of Oklahoma in 1950 with a B.S. degree in Geology. After a year of graduate work in Geology at OU, he joined Baroid Sales Division as a field service engineer. He is now working the southwestern Kansas and Oklahoma Panhandle area.

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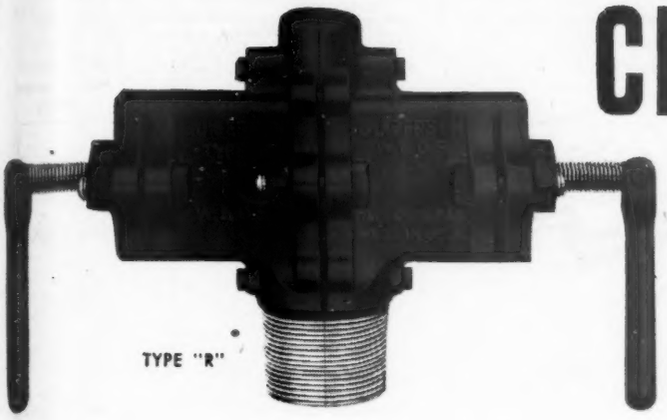

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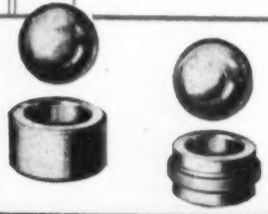

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Anadarko Basin

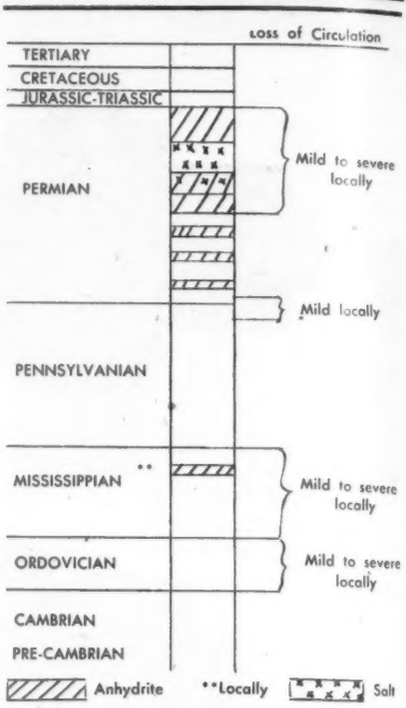

FIG. 1. Mud contaminant and loss of circulation log — northwestern Anadarko Basin.

counties in Kansas plus the Oklahoma Panhandle. The most active drilling areas are now in Meade County (Novinger, McKinney, and Adams Ranch fields), Seward County (Light field) and Clark County, Kansas, and in Beaver County, Oklahoma. Possibilities of finding commercial oil and gas exist in the Permian through the Pennsylvanian, Mississippian, and Ordovician. Problems affecting mud design and maintenance include loss of circulation, contamination with salt and anhydrite in the Permian, and limited quality and quantity of make-up water. The combination of salt contamination and loss of circulation involves a choice of casing programs, which in turn influences mud programs. Fig. 1 illustrates the conditions of lost circulation and mud contaminants existing in this general area.

The famous Hugoton gas field lies in the northwestern edge of the Anadarko Basin and produces from the Chase group of Permian age at a depth of from 2200 to 2800 ft. The high filter loss, (25-100 cc API) of muds, resulting from contamination by the Permian salt and anhydrite, is usually disregarded while drilling to the top of the pay zones. Drilling below the surface casing is rapid, requiring only 5 to 10 days. When casing is set through the productive formations and perforated, the productive zones are generally drilled with starch muds having 5-15 cc API filter losses. Some operators set casing on top of the pay zone and then complete the well with cable tools. Mud viscosities are generally carried in the 35-40 second API range, accomplished by the addition of a special salt water clay.

Salt concentrations is these muds range from 1 per cent to saturation.

Eastward into Seward, Meade, and Clark counties of Kansas and Beaver County, Oklahoma, drilling depths vary from 4800 to 9500 ft. Below the Permian salt and anhydrite, zones of lost circulation are encountered in the Pennsylvanian, Mississippian, and Ordovician. As mentioned before, loss of circulation is a constant hazard from the Permian through the Ordovician. Mud programs

General geologic section of S. W. Kansas and Oklahoma Panhandle including mud contaminants, lost circulation zones and known producing horizons.

System	Series	Group	Formation	Contaminants	Typical thickness	Loss of circ.	Known production
Tertiary					0–500		
	Gulfian	Colorado			0–475		
Cretaceous	Comanchean				0–100		
Jurassic			Morrison		?		
Triassic		Dockum		Gypsum	0–40		
	Guadalupian	Quartermaster		Anhydrite and gypsum	460	Mild to severe locally	
	Leonardian	Nippewalla	Blaine	Anhydrite, gypsum and salt	2000		
		Sumner	Cimarron				
			Wellington				
			Hollenberg	Anhydrite			
Permian	Wolfcampian	Chase	Herrington		300		Gas
			Paddock	Anhydrite			
			Krider				Gas
			Winfield				Gas
			Gage	Anhydrite			
			Towanda				Gas
			Holmesville	Anhydrite			
			Fort Riley				Gas
			Florence				Gas
		Council Grove	Cottonwood		400	Mild locally only	
			Neva				
		Admire			200		
Pennsylvanian	Virgilian	Wabaunsee			350		
		Shawnee	Topeka Oread		400		
		Douglas			up to 100		
	Missourian	Lansing			350–1200		Oil
	Des Moinesian	Marmaton			200		Oil
		Cherokee			50–500?		Oil
	Atokan				0–500		Oil
	Morrowan				0–600		Distillate andoil
Mississipian	Chesterian				0–300		Distillate
	Meramecian		St. Genevieve		550–900	Mild to severe, locally	Oil
			St. Louis	Anhydrite locally			
			Spergen-Warsaw				
	Osagian		Burlington-Keokuk		150–300	Mild to severe locally	
	Kinderhookian		Fern Glen		0–250		
Ordovician			Viola		100–200		Oil
		Simpson			0–90		
		Arbuckle			700–750	Mild to severe locally	
Cambrian			Reagan		0–75		
Precambrian			Granite				

Note — Siluro-Devonian absent in area.
Section prepared with the help of Doug Marden, geologist for United Producing Company, Satanta, Kansas.

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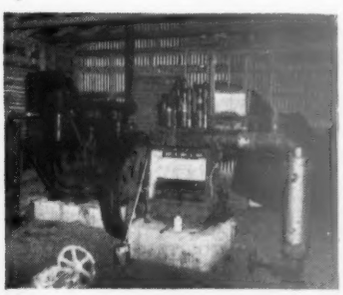

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vary considerably in this area depending upon the selected casing program. Usually the casing program calls for setting 10¾ or 13⅜ in. surface pipe 25 to 50 ft into the Permian Red Beds (300-600 ft deep). The Permian salt sections, or the Permian Chase Group are then drilled with a special salt water clay for maintaining mud viscosity in the 36-40 second API range. Filter loss is generally disregarded. In some cases starch is added to reduce the filter loss just prior to running intermediate casing. Salt concentrations of this mud will range from 10 per cent to saturation depending upon salt bed thickness. After setting 8⅝ or 9⅝-in. intermediate casing to depths of 2400 to 2900 ft through the salt section, the salt-water-mud is replaced by a bentonite fresh-water-mud. Control of mud properties is then usually begun near the base of the Permian or top of the Pennsylvanian. Fairly low filter losses are desirable to prevent sloughing of the shale and tight hole troubles. Soda ash, caustic soda and tannin, or humic type, thinners are used in these bentonite muds to overcome the effects of calcium contamination from anhydrite stringers or contaminated make-up water. Sodium carboxymethylcellulose is occasionally used as a filter loss reducing agent when low filtrate values are desired. Viscosities are not critical, but weights are maintained below 10 lb per gallon to minimize loss of circulation. Although excessive formation pressures are seldom encountered, holes must be kept full of mud while making round trips to prevent influx of water from the shallow basal Permian salt water sands. Typical properties of conventional muds used below intermediate casing are shown in the following tabulation:

Depth, feet	3750	4541	5200	5708
Weight, lb per gal	9.6	9.4	9.7	9.5
Viscosity, sec. API	32	40	45	53
Initial gel strength, Stormer, g.	0	5	0	0
10 min. gel strength, Stormer, g.	15	30	10	20
Filter loss, cc., API	16	8	6.8	9.2
Cake thickness, 32nd inch	2	2	1.5	2
pH	11	10.5	10.5	10
Salinity, ppm NaCl	5950	8250	8250	6600

Oil emulsion muds are frequently used to drill below the salt sections because of their lower density, lower filter loss, and lubricating characteristics. The emulsion muds also permit faster drilling rates. Typical properties of an oil emulsion mud used below intermediate casing are listed below:

Depth, feet	3598	4617	5280
Weight, lb per gal	9.1	9.2	9.6
Viscosity, sec, API	33	42	48
Initial gel strength, Stormer, g.	0	0	0
10 min. gel strength, Stormer, g.	0	10	20
Filter loss, cc, API	6	4.4	4.4
Cake thickness, 32nd inch	1.5	1.5	1.5
Salinity, ppm NaCl	7500	4950	4950
pH	10	10.5	10.5

Mud programs also are designed for drilling below the Permian without setting an intermediate "salt string." In these salt muds a special salt water clay is used for viscosity control; modified starch and preservative are added when it becomes necessary to reduce the filter loss to the 5-15 cc range. It is not usual to control the filter loss until drilling depths reach the basal Permian or upper Pennsylvanian. Control is then exercised until total depth is reached. The supply of intermediate casing and the economics of casing cost versus increased mud costs are the factors that are considered in selecting the mud type to be used in the lower part of these holes. Loss of circulation in the lower Permian, upper Pennsylvanian, Mississippian and Ordovician are constant hazards and the higher unit weight salt-water-muds (10 lb per gallon or higher) tend to aggravate these losses.

All common lost circulation materials are used in this area. Severity of mud loss at different horizons within a well, and from area to area, vary in magnitude and location as indicated in Fig. 1.

General geologic section of the Golden Trend including mud contaminants, lost circulation zones and known producing horizons.

System	Series	Group or formation	Contaminants	Typical* thickness	Loss of circulation	Known production
Permian	Wolfcamp	Pontotoc	Salt water from shallow sands (locally)	4000?		
Pennsylvanian	Virgil			3250	Mild Locally	
	Missouri	Hogshooter				
		Layton				
		Checkerboard				
	Des Moines	Deese				
		Dornick Hills				
	Morrow					
	Springer	Springer				Oil
Mississipian	Chester	Caney		100		
	Osage (Boone)	Mayes		175		
	Kinderhook	Woodford		200		
Devonian	Hunton	Frisco		400		Oil
		Bois d'arc				
Silurian		Haragan-Henryhouse				
		Chimney Hill				
Ordivician		Sylvan		200		
		Viola		550		
		Simpson		1350		Oil
		Arbuckle		425		
Cambrian						

* Due to processes of sedimentation and faulting, formation thicknesses vary widely throughout the region. Typical thickness shown represent averages for the Lindsay area in McClain and Garvin Counties.

Reference: (Geological section and sequence only)
"Anadarko Basin—Geology and Possibilities, Rob't. W. Wheeler; World Oil, September 29, 1947.
Oil and Gas Field Development in United States, National Oil Scouts and Landmen's Association, Year Book, 1949, Vol. XIX.

West Central Oklahoma

Drilling of the Paleozoic, to the east and south of the above described area, generally involves greater drilling depths and less contamination of the mud from the Permian evaporites. These evaporites grade from their maximum development in the west into shales and sandstones towards the east and south.

Mud programs compare with those previously described for wells drilled along the north flank of the basin. If the salt contamination from the Permian is high enough to require the use of muds containing modified starch, wells are usually completed below the Permian without setting intermediate casing. If salt contamination of the mud is below 3-4 per cent bentonite muds treated with soda ash, caustic soda and organic thinners are used to drill below the Permian. Wells drilled in parts of Kay, Noble, and Logan counties and to the east use chemically treated bentonite muds. Loss of circulation is locally severe in the Mississippian.

The deepest part of the basin is along its southern rim near the north front of the Wichita Mountains (Washita, Beckham, Roger Mills, and Custer counties, Oklahoma). Here, drilling involves penetration of several thousand feet of Permian and Pennsylvanian. The Permian is drilled to approximately 6500 ft and middle Pennsylvanian rocks (Des Moines) are drilled to below 14,000 ft.

In this part of the basin it is common practice to set intermediate casing below surface or conductor pipe through the Permian salt and most of the Permian anhydrite. Setting depths range from 3100 ft to 3600 ft. Salt water type drilling muds are maintained with "salt water clay" for viscosity control and little consideration is given to filter loss. Viscosity of 31 to 33 sec API is usually sufficient until the hole is drilled to about 200 ft above the casing point. Then it is increased to 60-85 sec in order to prevent settling of cuttings when running electric logs and casing. Loss of circulation between 600-1000 ft may become severe. Properties of a typical mud for setting intermediate casing are shown as follows:

General geologic section of Elk City Field including mud contaminants, lost circulation zones, and known producing horizons.

System	Series	Group	Formation	Contaminants	Typical thickness	Loss of circ.	Known production
Permian	Guadalupe	Kiger	Quartermaster	Gypsum	405	Mild to severe locally	
			Cloudchief	Anhydrite	280		
			Rush Springs	Gypsum and anhydrite	375		
			Marlow	Gypsum and anhydrite	290		
	Leonard	Salt Fork	Dog Creek	Gypsum and anhydrite	290		
			Blaine		270		
			Hennessey-Garber	Salt and anhydrite	1925		
	Wolfcamp	Chase Sumner	Wellington Pearl	Anhydrite	2945	Mild to severe locally	
		Council Grove					
		Admire					
Pennsylvanian	Virgil				1800		
	Missouri (Hoxbar)	Kansas City			1630		
		Bourbon Bronson			460		Gas, distillate and oil
	Des Moines	Deese			2935		High pressure gas (locally)

Reference:
Geological section (except depths) adapted from preparation by Robert J. Beams. Sunbeam Oil Corporation (Oklahoma City).

Weight, lb per gal	10.4
Viscosity, sec, API	60
Filter loss, cc, API	80
Cake thickness, 32nd inch	6
pH	7
Salinity, ppm NaCl	130,000
Calcium ion, epm	20

From below the intermediate casing to near the top of the Pennsylvanian a fresh water base drilling fluid is used. Heavy water dilution is required to prevent native solids build-up from increasing the mud weight above 9.2 to 9.4 lb per gallon. Higher weights would aggravate lost circulation conditions to near the top of the Pennsylvanian. As filter loss is not critical through this portion of the hole, only salt water clay and bentonite are used to maintain sufficient viscosity for lifting cuttings. Viscosities normally range between 32-34 sec, API although unusual conditions may require higher viscosities. Due to the large amounts of water added, the concentrations of sodium chloride and calcium sulfate in the mud are kept fairly low. These contaminants come from stringers below the intermediate casing and are reduced to controllable quantities by the time chemical treatment is begun. Bentonite is substituted for salt water clay as a viscosity control agent when the concentration of contaminating salts is finally reduced to required values. Just before bentonite is added, pit volumes are reduced by jetting and the remaining calcium ion concentration is further reduced by treatment with soda ash or barium carbonate. This process takes places while drilling in basal Permian (6000 to 7000 ft). At approximately the top of the Pennsylvanian, caustic soda, soda ash, and organic thinners are introduced for reducing filter loss to 8 to 15 cc API. The following are the properties of a typical mud used in the Beckham County, Elk City field, for drilling the productive Missouri series (Pennsylvanian) from 9000 to 10,500 ft.

Weight lb per gal	9.2 to 9.4
Viscosity, sec, API	50
Initial gel strength, Stormer, g	0
10 minute gel strength, Stormer, g	15
Filter loss, cc, API	8 or less
pH	10

Loss of circulation is a localized problem when encountered below the intermediate casing through the Permian and into the upper Pennsylvanian. In the Elk City field, mud weights are not critical until the top of the Pennsylvanian is reached. Then they must be reduced in order to minimize the effect of hydrostatic head on loss of circulation. In western Beckham, Roger Mills, Ellis, Dewey and Custer counties, severe loss of circulation occurs in parts of the lower Permian as well as the upper Pennsylvanian. Lost circulation materials have been added in concentrations as high as 25 lb per barrel for overcoming mud loss. Under such conditions, control of mud weight often becomes critical and tedious. They involve a close balance between hydrostatic head and formation pressures.

When drilling depths extend below the Missouri Series of the Pennsylvanian, higher formation pressures may be encountered. These Pennsylvanian shale sections also require filter loss reduction to 4 to 6 cc API to improve hole conditions. Mud weights above 16 lb per gallon, requiring the use of barytes, have been used on the deeper exploratory wells. Heavily weighted muds generally consist of high-pH-caustic-tannin or humic treated bentonite muds; high-pH-oil-emulsion muds; or high-pH-lime muds. These deeper programs require the setting of a long casing string through the loss of circulation zones of the Permian and upper Pennsylvanian formations.

South Central Oklahoma

Mud programs in the southeastern part of the Anadarko Basin and in the region of Grady, McClain, Garvin, and Stephens counties of Oklahoma are a modification of these described above. Mud design and maintenance are characterized by the type of drilling which involves the penetration of long sections of steeply dipping formations. Although the Permian section is drilled in this area, it comprises a relatively small portion of the total well footage and is free from the mud contaminating effect of sodium and calcium salts. The Pennsylvanian, Mississippian, Devonian-Silurian, and Ordovician comprise the major portion of the formations encountered. The mechanical aspects of drilling techniques are important factors in hole performance while drilling the long shale sections.

This well developed area contains numerous fields producing mostly from rocks of Pennsylvanian and Ordovician age. The Deese and Springer series of the Pennsylvanian are prolific petroleum sources, particularly in the southern provinces. The Simpson group of lower Ordovician is also extremely productive. Typical stratigraphic traps predominate in this area which is characterized by many faults and steeply dipping formations. Production is derived from depths of 500 to 13,000 ft. The greatest variation in producing depths and the steepest dipping formations occur near the southeastern part of the basin. Some producing sands in southern Oklahoma have been found to dip as great as 88 degrees.

The depths at which mud control is initiated depends upon hole conditions. Control of filter loss and viscosity become necessary when movement of drill pipe is difficult or restricted and associated troubles occur on trips. In some locations wells may be drilled to 6500 ft without mud additives, while in other areas, perhaps only a short distance away, the mud should receive attention at 1000 ft. These wide variations are due to the faulted condition of the formations and the variable thickness of the Permian. The Permian, in this area, can usually be drilled successfully with native mud. It has relatively little dip and little tendency to slough or cave. Higher rates of water dilution are required through the Permian to control the mud weight that would increase rapidly from the entrainment of low specific gravity formation solids. As the Pennsylvanian shale sections (Dornick Hills and Springer) are penetrated, the mud is treated to reduce the filter loss and increase the viscosity. Depending upon mechanical factors, and length and dip of the shale sections, muds are main-

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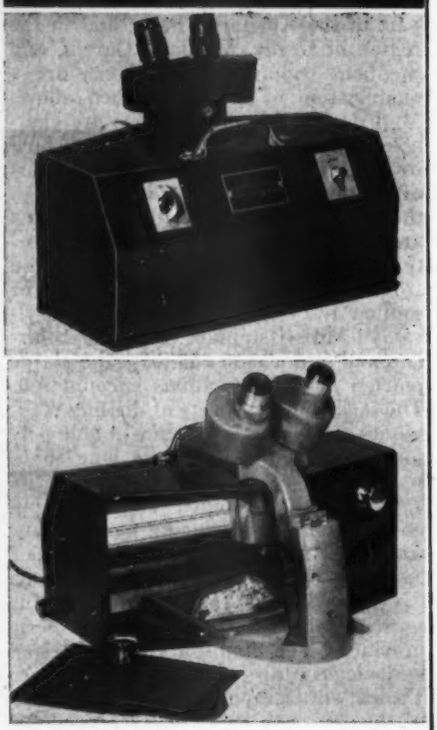

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tained at weights approximating 10 lb per gallon, viscosity of 70 to 200 sec, API, zero gel strengths (Stormer) and less than 6 cc API filter loss. These shale sections are very treacherous and may cause serious drilling difficulties. Hole enlargements through the shale sections, caused by high filter loss mud or erosion by the drill pipe, promote the accumulation of shale cuttings and cavings that may later dump into the hole causing trouble on trips and stuck drill pipe. Low, flat gel strength muds are capable of reducing these accumulations. Shale erosion and hole enlargement are aggravated when drill pipe is carried in compression. High mud viscosities and proper gel strength control are often required to remove abnormal quantities of shale.

Contamination of muds by sodium and calcium salts is slight and usually originates in make-up waters. Soda ash, barium carbonate and organic thinners are capable treating agents for counteracting the effects of these contaminants. Particular attention, however, should be given to keeping the hole full on round trips to minimize the entry of salt water from shallow sands.

In comparison to other parts of the basin loss of circulation is not severe. Loss of circulation is most likely to occur in the several Pennsylvanian sands or Mississippian limestones. Mud weights, however, should be maintained around 10 lb per gallon. In certain areas mud is lost with a weight as low as 9 lb per gallon while other areas can tolerate 12 lb per gallon. A treatment with 2 to 3 lb per barrel of lost circulation material and reduced pump volumes will usually correct such losses. When loss of circulation occurs, the resulting reduced hydrostatic head may permit the entry of salt water or gas from shallow sands. This requires corrective measures in the mud treatment or preparation of new mud.

High formation pressures are not common in the area. Pennsylvanian sands in the Springer series, however, may require weighted muds for control of formation pressures. Where these sands are encountered at shallow depths, in the highly faulted areas of southern Oklahoma, the mud weight required to control these pressures often results in loss of circulation into shallower upper zones. To meet these conditions the muds are prepared with lost circulation and weighting materials. Where these high pressure sands are encountered at greater depths, such as the Britt sand (Pennsylvanian Springer) at 11,500 ft in the Chitwood area of Grady County, long casing strings are set above the high pressure zone as protection against loss of circulation and the muds are weighted with barytes for drilling ahead. Mud weights from 13 to 14 lb per gallon are required to control formation pressures in a few localized areas.

Bentonite muds treated with caustic soda and tannin or humic thinners predominate in the general area. Soda ash or barium carbonate sometimes are used for removal of calcium ion. Average characteristics of muds used in the Golden Trend area of Garvin, McClain and Grady counties are as follows:

Depth (feet)	Weight (lb per gal)	Viscosity (sec API)	Filter loss (cc API)
5000	Mud-up depth		
5356	10.0	38	8.4
5644	10.0	41	6.8
5900	10.0	44	8.0
6228	10.1	42	7.6
6476	10.1	44	8.0
6640	10.2	44	6.4
6857	9.9	52	6.4

As was mentioned before, viscosities may be increased and filter losses reduced from the average values shown in the tabulation when hole conditions become difficult. Filter losses are frequently reduced to about 4 cc API by the addition of bentonite, sodium-carboxymethyl cellulose and organic thinners.

Oil emulsion muds, usually of the low pH type, using about 10 per cent oil, have been widely used in this portion of the basin. The advantage of low filter loss and added lubricity make these relatively inexpensive oil emulsions very useful in this "fesh water" mud country.

Summary

Drilling mud control in the Anadarko Basin uses the same basic principles and materials as control in other areas. The two main problems are (1) loss of circulation and (2) mud contamination with soluble salts.

Loss of circulation may be minimized by adding water to prevent mud weight increases due to entrainment of excessive amounts of formation solids. When lost circulation occurs the conventional materials and methods are used to combat the loss.

Contaminants are predominantly calcium-sulfate and sodium chloride. The quantity of contaminants, hole conditions, and casing programs are the factors having the most influence on the selection of a mud treating program.

With the exception of contaminated surface make-up waters the zones of lost circulation and contaminants are fairly well known. These are associated with formations of identifiable geologic age. Therefore, the use of such terms as Permian, Pennsylvanian, etc., are much more common, when mud is being discussed, than are similar terms in other parts of the country. ★ ★ ★

CITIES SERVICE STAKES NEW TEST IN ANADARKO

A 9500-ft wildcat for Woodward County, Oklahoma, has been announced by Cities Service Oil Company (Delaware) at its Drake B No. 1.

The rank wildcat will test the Tonkawa, Layton, Cherokee, and Morrow sandstones and the Chester and Mississippian limestones. Nearest production is approximately 45 miles east in the Ringwood pool.

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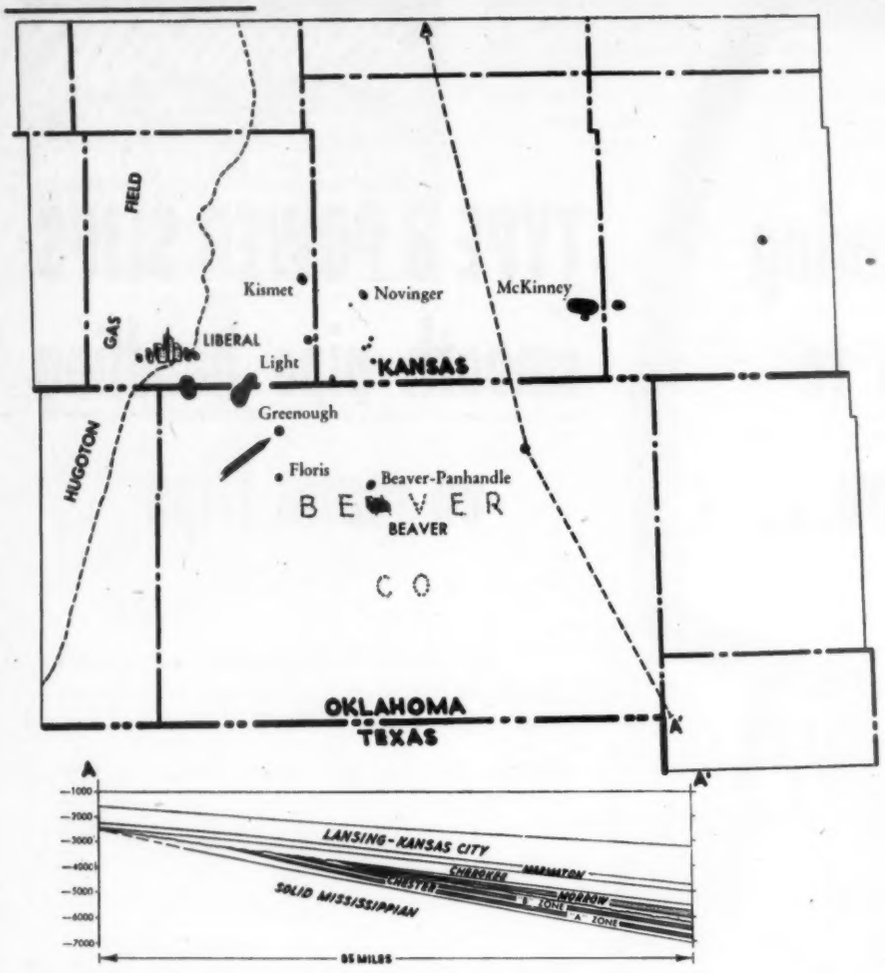

FIG. 1. Index map of Beaver County area.

Beaver County, Oklahoma

GREENOUGH POOL

J. R. KYLE

Well head assembly at No. 1 Breen, east offset to discovery well at Greenough field, Oklahoma Panhandle, framed against typical Panhandle scenery.

Area of Promise

In Oklahoma's pre-statehood days, the Oklahoma Panhandle was a wild and unclaimed no man's land. Today wheat farmers and cattle ranchers have replaced the outlaws who once sought sanctuary in its lawless environs, but to the petroleum geologist, the 5700 square mile area in the strip is still geologically wild and relatively unknown.

The area of greatest current interest and activity is Beaver County, easternmost of the three Panhandle counties, and the adjoining portions of Seward and Meade counties, Kansas (see Fig. 1). Prior to 1945, drilling activity in this area was desultory and inconclusive, and exploratory work, which included surface geology, core drilling, and geophysical prospecting, was sporadic and considerably handicapped by the mantle of Tertiary sediments and alluvium that masks most of the county.

In 1945 Stanolind discovered the Adams Ranch pool with its No. 1 Adams, in the SW corner of 8-35S-30W, Kansas, just north of the Beaver County-Meade County line. Although no more producers were drilled, the discovery was significant in that it found production in an entirely new horizon for this region—the Mississippian Chester. Production was gas and gas-distillate. This success provided impetus to further prospecting in the area, and since 1945 a substantial number of discoveries have been made, largely in the two previously mentioned Kansas counties. The first Beaver County production was obtained in 1947 with the discovery of the Southeast Liberal and Light pools, by Stanolind and H. L. Hunt, respectively. Both of these pools sit astride the Kansas-Oklahoma line and produce gas and distillate from Pennsylvanian Morrow sands.

Early in 1952 activity in Beaver County sharply accelerated following the drilling of the Pure No. 1 Albert, 16-5N-26ECM, which was completed as a gas well in the Morrow, and Flynn Oil Company's No. 1 School Land, 35-5N-23ECM, discovery well of the Beaver-Panhandle pool. In the latter, a thick series of limestones between the Lovell and Cherokee yielded several

The Author

J. R. Kyle is division geologist for Carter Oil Company in Oklahoma City.

A graduate of Carleton College, Northfield, Minnesota, Kyle joined Carter in 1939 in the exploration department. He received a military leave in 1942, returning to the company in 1945 where he served as office geologist and senior geologist for the Northwest division. He was named assistant to the exploration manager in Tulsa in 1948, and was named to his present position in February of this year.

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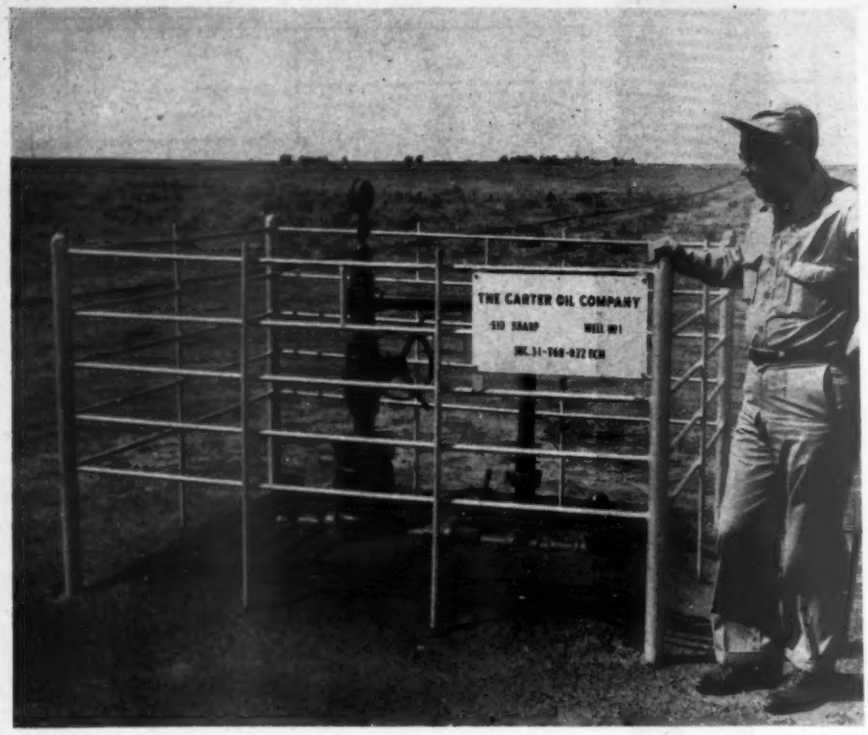

Bill Dancey, Carter production foreman, stands beside wellsite of Greenough pool discovery well.

shows, with initial completion being 105 bbl of 41 deg gravity oil per day, plus 8 bbl of water, from the Pennsylvanian (Marmaton) Big Lime. After drilling two offset dry holes, the operator plugged back and completed a small pumper from a Douglas lime.

The majority of the earlier discoveries were productive only of gas and distillate from Morrow and Chester. A notable exception is the Novinger pool, 33S-30W, Kansas, which was discovered in 1951 by Columbia Carbon and United Producing No. 1 Novinger and completed in Marmaton limestone for 1675 bbl of 41 deg oil daily, plus 327 Mcf gas.

The first substantial oil production in Beaver County was obtained in The Carter Oil Company and Kaye No. 1 Sharp, C SE SE 31-6N-22ECM, discovery well of the Greenough pool. This well, drilled to a total depth of 5867 ft, was completed on February 22, 1952, from a 19-ft Pennsylvanian Lower Oswego lime interval for an initial flow rate of 936 bbl oil and 1845 Mcfg per day through a 33/64-in. top choke, following treatment with 3000 gal of acid. Gravity of the oil is 41 deg. The casing program on the No. 1 Sharp included a protection string of 9⅝-in. pipe set at 2520 ft, in addition to the 531 ft of 13⅜-in. surface casing; however, the protection string was omitted on subsequent offset wells. Seven-inch oil string was run to total depth and perforated opposite the productive interval.

Development wells are being drilled on a 40-acre pattern. As of the end of September, 1952, there were three producers in the Greenough pool (the discovery well, plus the north and east offsets), one drilling well (northwest diagonal offset), and one dry hole (southwest diagonal offset). The latter unsuccessfully tested the Mississippian, and although oil and gas were recovered on a drillstem test of the Big Lime overlying the Oswego, it could not be successfully completed as a producer. The second and third wells at Greenough were completed in July, 1952, for initial flow rates of 480 and 360 bbl oil per day, respectively, following a 2000 gal acid treatment for the second and application of 500 gal of mud acid to the third.

Another wildcat effort by The Carter Oil Company, two and one-half miles to the southwest, 2-5N-21ECM, tested the Mississippian to a total depth of 6976 ft and drew a blank, but a third test slightly over four miles due south had better luck. This well, the No. 1 Dorman, C NW NW 29-5N-22ECM, had moderate oil recovery from two drillstem tests in the Avant-Lansing section and substantial recoveries plus some salt water from three tests of a 37-ft section of limestone immediately overlying the Big Lime. The well was ultimately completed in the latter zone for a flow potential of 114 bbl oil per day, plus 22 bbl water. This area has been called the Floris pool. An offset confirmation well is currently drilling.

Fig. 2 portrays a typical electric log for the Beaver County area. The well is the Huber No. 1 Heintz, 15-6N-21ECM, a development well in the Light pool, which was completed as a producer in the Morrow. It was selected for the purpose because it penetrated the Chester and gives a fairly typical picture of more potentially productive zones in the gen-

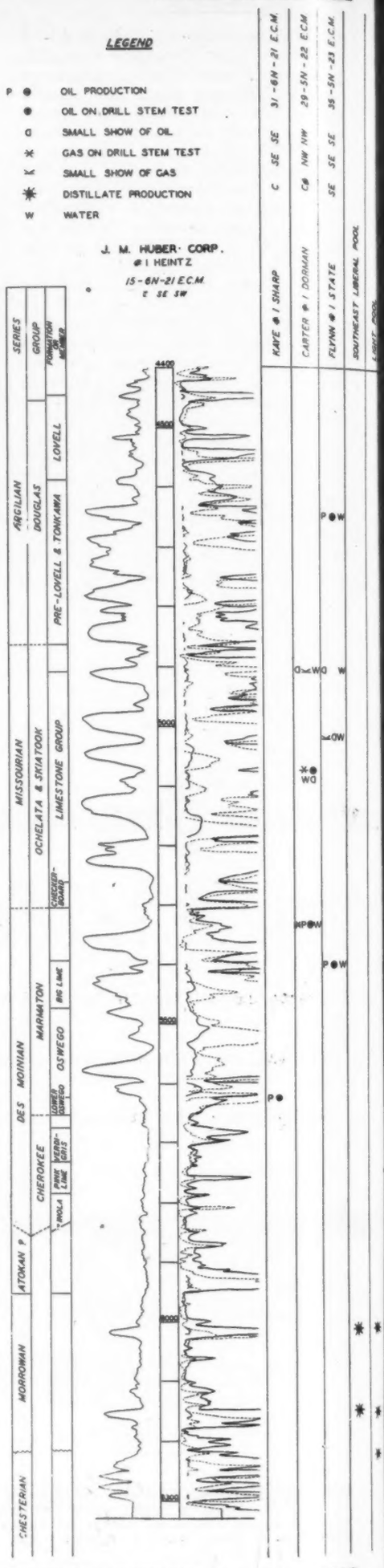

FIG. 2. Typical electric log in Beaver County area.

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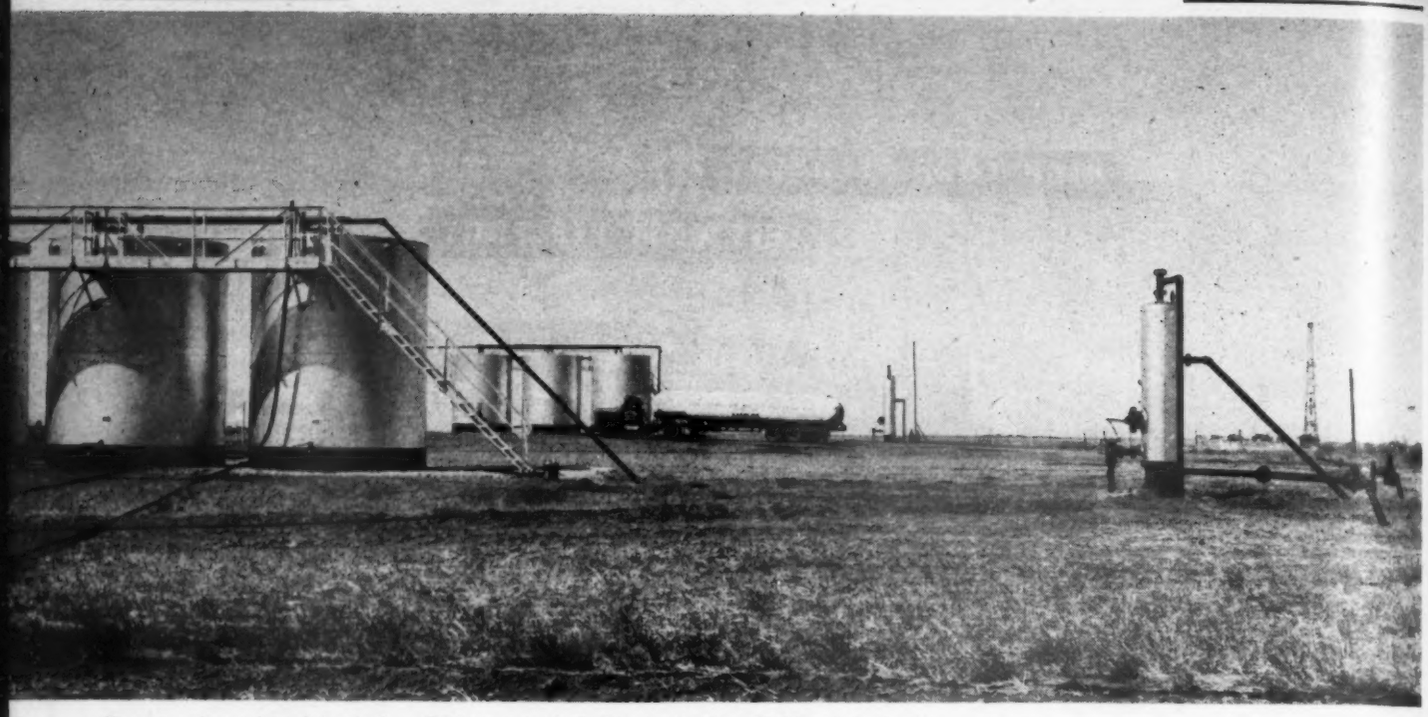
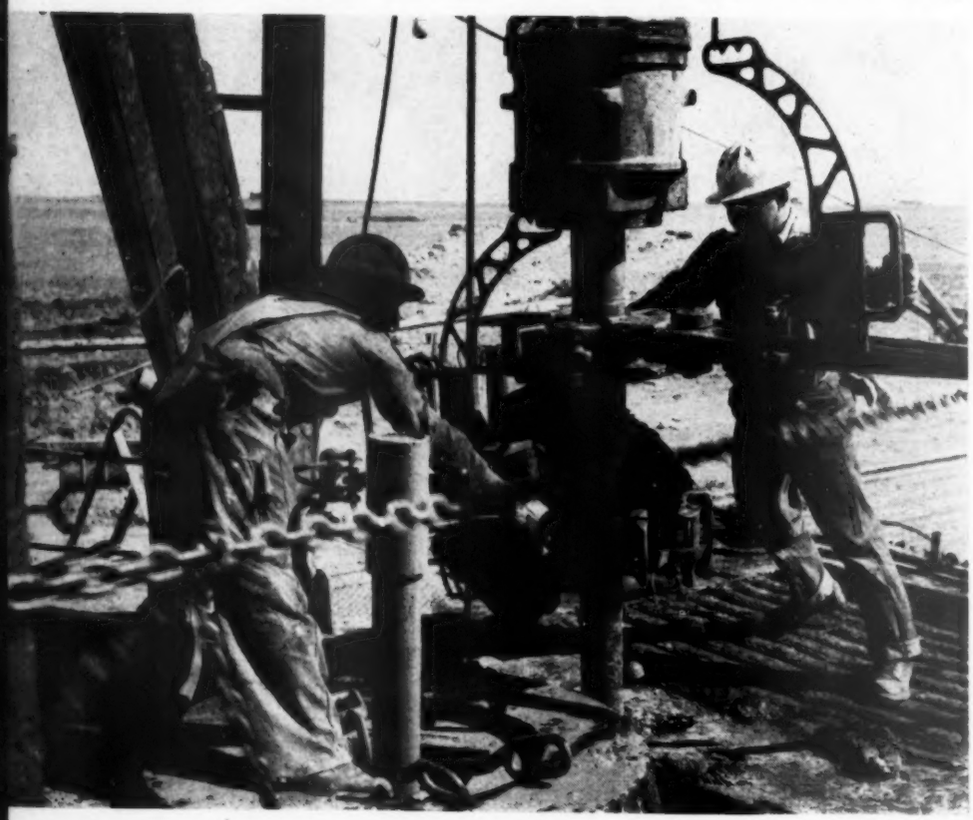


Greenough pool tank batteries. Oil is currently being trucked to Shallow Water, Kansas.

eral area than do any of the Greenough well logs. A stratigraphic chart is shown at the left, correlated with the electric log, and the symbols to the right indicate zones of production and shows in some of the important wells and pools in the Beaver County area.

The cause of accumulation of oil at Greenough and Floris is still a matter of some conjecture. There is considerable doubt that production is structurally controlled; subsurface data from wells thus far drilled indicate a relatively uniform southeast regional dip. The rather erratic distribution of shows in adjoining wells and lack of continuity of producing zones suggest the likelihood that accumulation is the result of porosity variables in the Pennsylvanian limes, which are unrelated to existing structure but which may be developed in localized areas.

Drilling crew on Carter's No. 3 Sid Sharp in the Greenough pool prepares to add another joint of pipe to the drill string in the hole. Man on the right is Clarence Coahley.



On Fig. 1, the index map of the region, is shown a generalized cross-section extending from the north line of Meade County, Kansas, to the southeast corner of Beaver County, Oklahoma. This illustrates the present conception of possible truncation and wedgeout traps in the Mississippian Chester series and Pennsylvanian Cherokee and Morrow. The Marmaton limes, which include the productive intervals in the Beaver-Panhandle, Greenough, and Floris pools, however, are known to persist far to the north and preclude any possibility of the oil accumulations being attributable to pinchouts or truncation traps. The fact that these limestones have a continuity of similar lithologic characteristics throughout the region also discounts the possibility that accumulation may be due to reef development, although this idea gained widespread consideration following Flynn's Beaver-Panhandle discovery when a few geologists interpreted the samples and electrical log as being rather typical of a reef.

A fair amount of core drilling and seismograph work has been done in the area by a number of companies and a few localized anomalies have been found. It is probable, however, that no major structural trends or flexures are present, and evaluation of the significance of the local features as possible oil traps must await further drilling. If production is controlled solely by porosity belts, much subsurface study and additional data will be required before any predictions can be made as to extent and trends of production. * * *

HUGHES TOOL COMPANY
RESEARCH AND ENGINEERING
LABORATORY

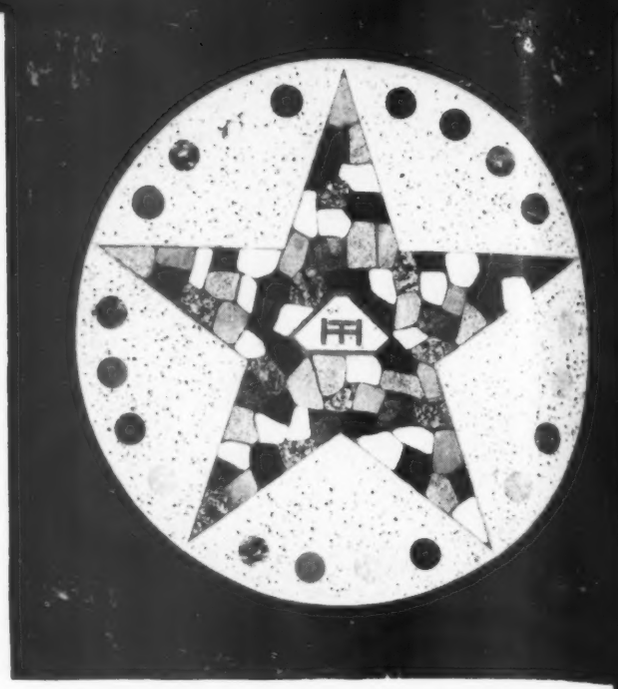
NEW HUGHES LABORATORY EXPANDS SCOPE OF DRILLING RESEARCH

The facilities of its new Research and Engineering Laboratory will enable the Hughes Tool Company to broaden the scope of its engineering activities related to the development of improved drilling tools.

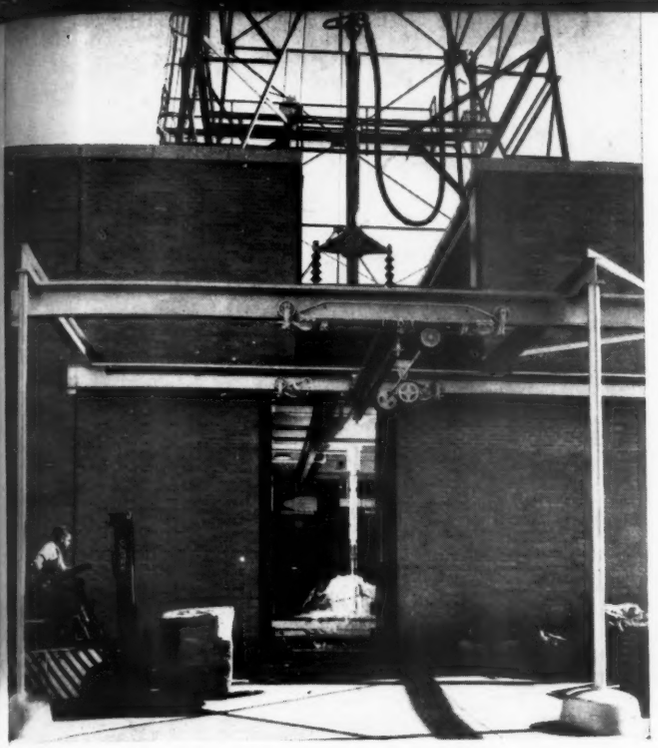
The new Laboratory is an "Engineering Pilot Plant" where Research, Product and Metallurgical Engineering plans and ideas are converted into reality.

Six laboratory sections and a modern machine shop are housed in the Research and Engineering Laboratory building. These are: Drilling, Product and Product Part Mechanical Testing, Metallographic, Chemical, Heat Treating, and Welding. The building is of brick and stone construction and is 325 ft. long, 120 ft. deep with a two-story center section. The total floor area is approximately 60,000 sq. ft.

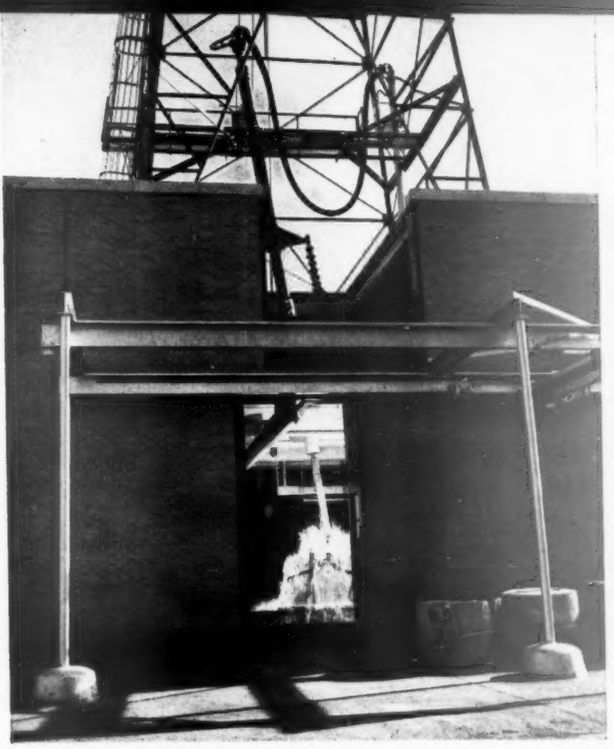
Research, of course, is not new at Hughes. The industry's and world's first "drilling research laboratory" — to study the performance of rock bits — was established by Howard R. Hughes, Sr., in 1910. In recent years the laboratory facilities have been repeatedly expanded, culminating in the building of the new laboratory, regarded as the finest of its kind, devoted to the drilling industry.



The decorative star-shaped insert in the center of the lobby floor is an arrangement of rock pieces from formations used for drilling tests by the Laboratory. The 20 round pieces between the points of the five-foot star are sections of cores obtained from major oil producing areas of the United States.



In this view of the drilling rig are shown derrick, swivel, drill stem, "V" window, hydraulic pulldown yoke for applying load on the bit, and "cellar" — the laboratory room in which test blocks are drilled. The derrick rising above the Laboratory roof is 118 ft. tall.



Inclined drilling is one of the many special investigations carried on with the Laboratory drilling rig. In these tests the drill stem can be inclined as much as 10 degrees. This type of experimental drilling has furnished valuable information relative to the problem of straightening crooked holes.

FIELD-SIZE DRILLING RIG USED IN LABORATORY DRILLING

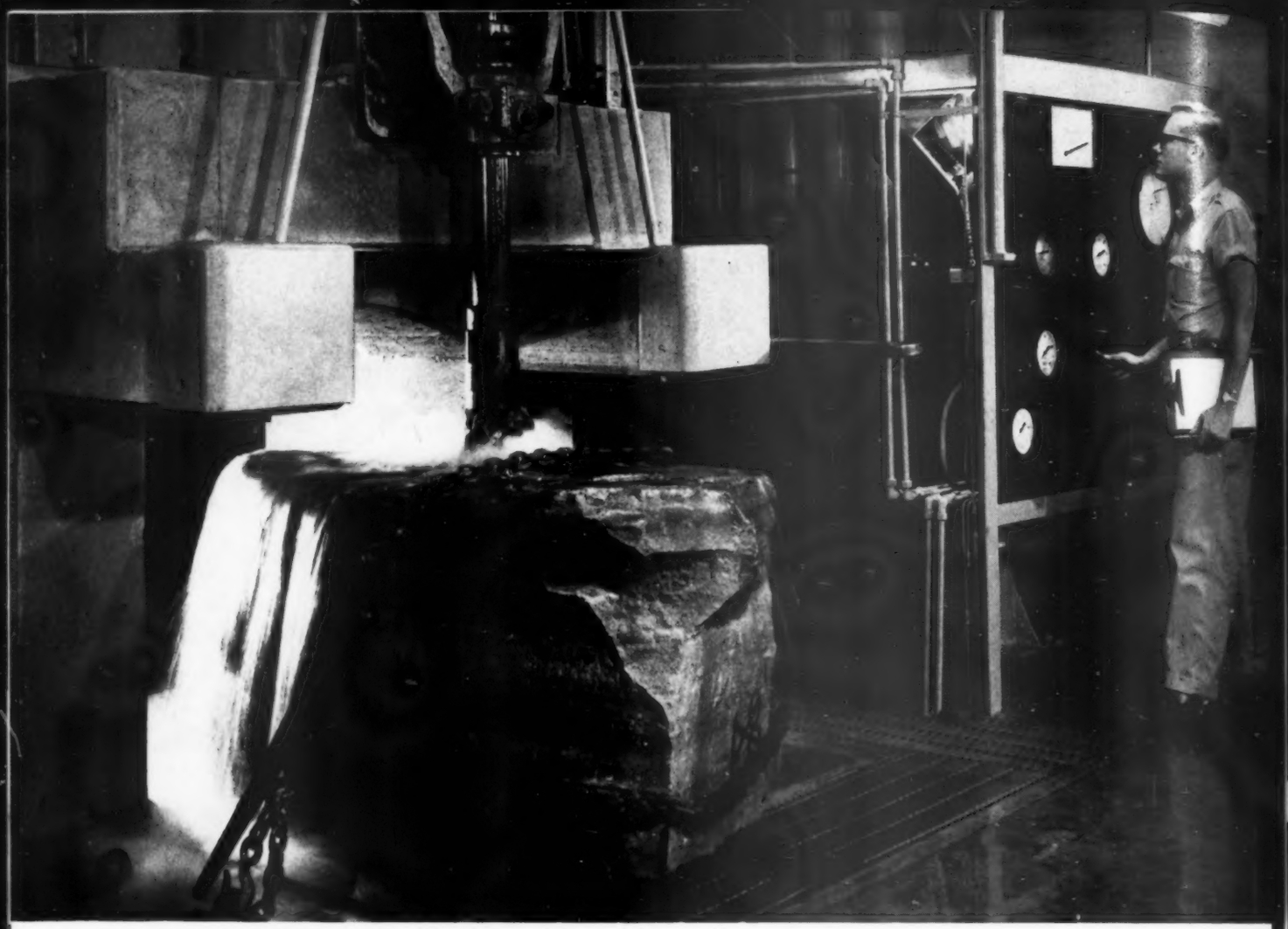
The fundamental purpose of all Hughes rock bit research is to improve rock bit performance.

In attaining this improvement it is necessary to balance design with the application of correct metallurgical materials and processes.

The preliminary proving ground is the Drilling Laboratory housed within the main Laboratory building. Its field-size drilling rig, with 118 ft. derrick, was specially designed to test rock bits in a manner simulating oil field drilling conditions. Variable drilling loads as high as 100,000 lbs. can be applied to the bit with rotational speeds up to 400 R.P.M.

Test blocks of rock, used in these drilling tests, are taken from many states throughout the country and are selected to approximate the drillability of formations encountered in the various oil fields. These test blocks are used to evaluate designs, materials and metallurgical processes.

Drilling is controlled by an operator seated in the booth shown above the test block. The rotary table that drives the drill stem is located on the "deck" of the rig at a level corresponding to the working floor of a field rig.

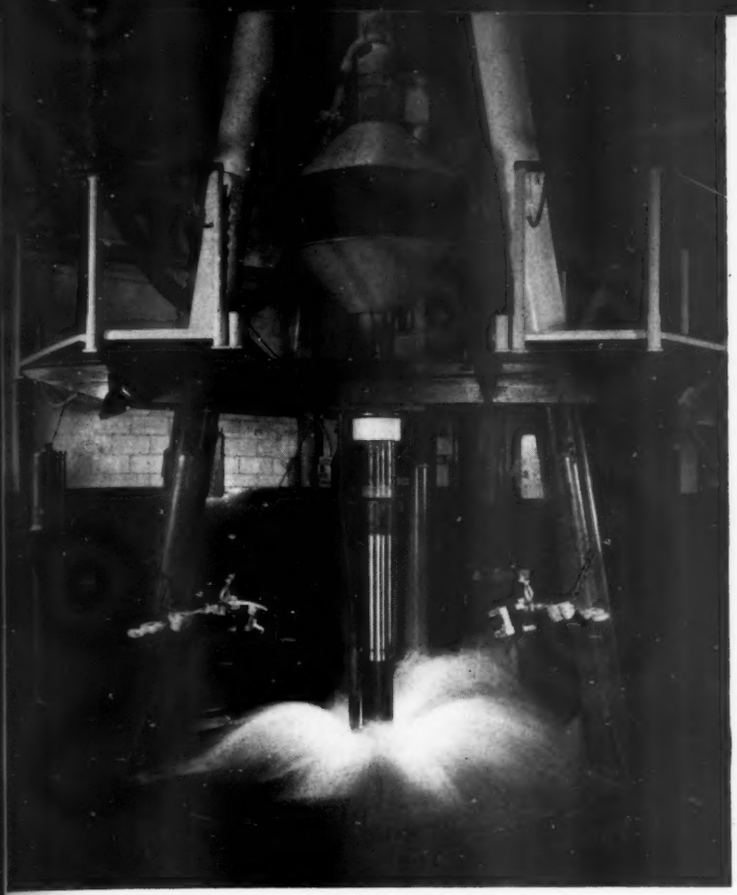


AUXILIARY DRILLING RIG. This small rig is capable of applying loads up to 50,000 lbs., at speeds up to 90 R.P.M. The operator in the above photograph is starting a hard formation drilling test and is studying the readings of a drilling rate indicator. A Hughes development, the indicator tells the operator the actual rate of penetration being made by the bit, instantly indicating every change in progress.

MICROBIT USED IN ESTIMATING ROCK BIT PERFORMANCE

The Microbit shown here is 1¼" in diameter. It is used in drilling cores and rock samples from all parts of the world.

Examination of the data obtained during the microbit drilling gives Hughes engineers information for estimating the performance of full-size bits in the same type of rock formation. The microbit drilling tests provide a good basis for picking the proper type of bit to be used in specific formations and in recommending the operating conditions that will give the best results.



PERCUSSION DRILLING TEST EQUIPMENT

The Drilling Laboratory is equipped to test new drilling techniques as well as new tools. The test equipment shown at the left was designed primarily for use in the development of rotary-type percussion drilling tools and bits.

At the time this photograph was taken a time-displacement diagram was being made to determine the cyclic characteristics of a fluid-actuated percussion tool. The entire "A" frame is supported on a reinforced concrete foundation mounted on large helical springs to reduce vibration.

TESTING HIGH VELOCITY JET BIT

In the development of Hughes jet rock bits emphasis has been placed on high velocity jetting action and bottom hole flow pattern.

The photograph at the left shows a test being conducted to observe the action of various types of jet nozzles.

The pressure drop across the bit and the velocity of the drilling fluid are important factors affecting the penetration rate of the bit. It is necessary that the fluid jets have sufficient velocity to remove the cuttings from bottom and keep the cutters clean.

The pressure assembly at the right in the photograph is used in studying fluid jetting action of individual nozzle outlets on drilling formations.

STUDY OF "DULLS" AIDS IN THE ADVANCEMENT OF DESIGN AND METALLURGY

The cycle in the study of new bit designs, materials, and processes of manufacture is not concluded until bits used in the field have been returned to the Laboratory for inspection by Research, Product and Metallurgical Engineers.

Combined with the laboratory tests, field trials predict the performance of new materials, processes, new bit design or a design change in a standard bit. Trial groups of bits are run under the observation of Hughes field engineers who return the "dulls" to the Laboratory along with the complete performance record of each test bit.

Project studies of this type are regularly conducted in many areas on large groups of bits involving several sizes and types. The returned bits are examined externally and then disassembled for a thorough physical and metallurgical study. Information from these sources provides a reliable basis for engineering evaluations.

Section of Laboratory showing Hughes engineers examining returned bits together with their field performance records. This is a continuing study carried on throughout the year.

Above, the shop foreman is explaining to the lathe operator machining details on an experimental cone. Below, teeth are being milled on an experimental cone.

LABORATORY MACHINE SHOP MANUFACTURES TOOLS FOR FIELD TESTS

The Hughes Laboratory Machine Shop is devoted to the building of full-scale test models of rock bits, tool joints and other drilling tools for laboratory and field testing. In connection with the latter, this Shop is equipped to expedite the manufacture of these tools in sufficient quantities for extensive and immediate field trials.

The Machine Shop handles a large amount of work for the Research, Product and Metallurgical Engineering Departments in building new designs, new mechanisms and new devices requisitioned for preliminary testing or other experimental work.

The operator, above, is preparing to remove experimental bit cones from an atmosphere controlled heat treating furnace for quenching.

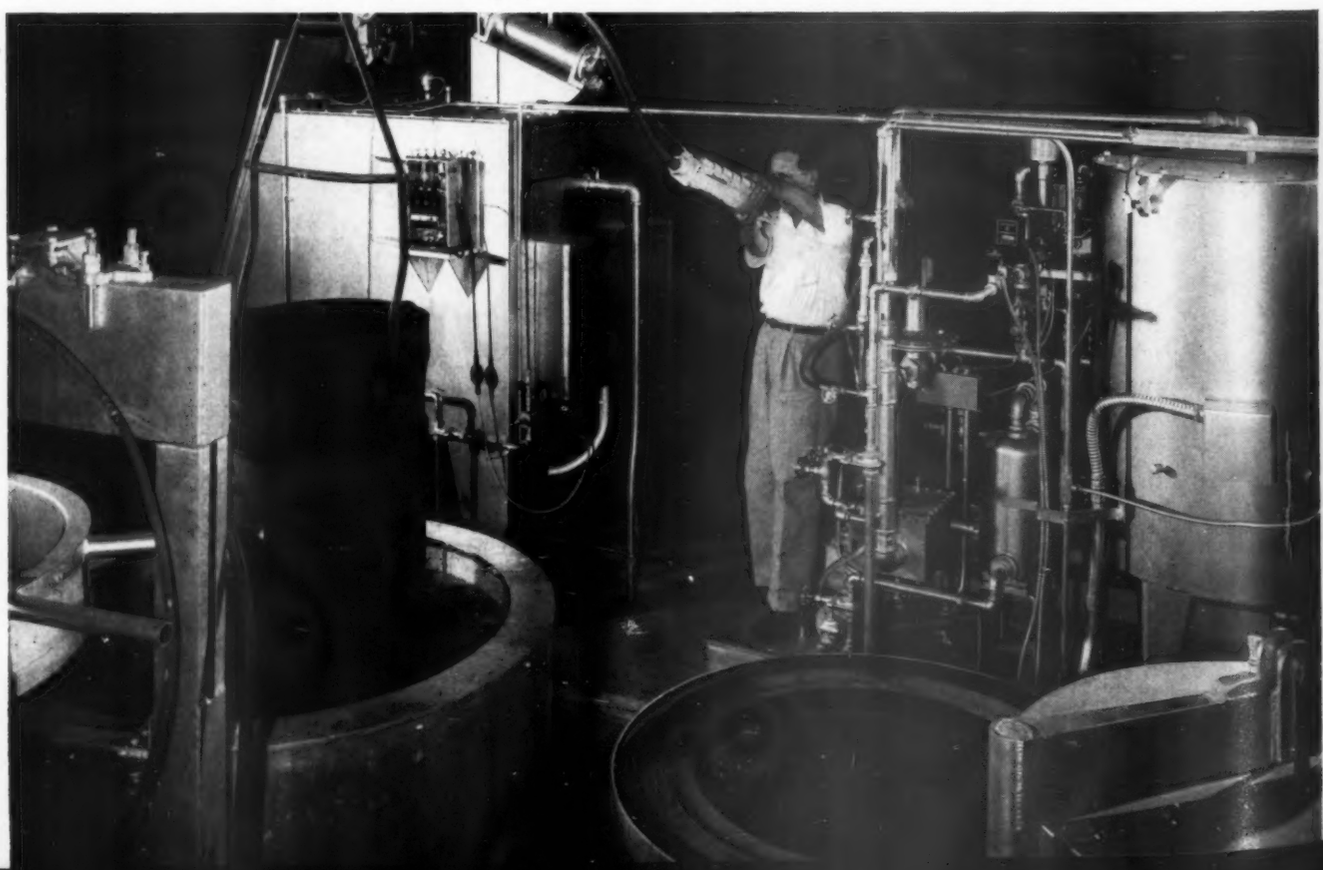
Controllers and temperature recorders for the Laboratory heat treating and carburizing furnaces.

COMPLETE LABORATORY HEAT TREATING FACILITIES

Metallurgy plays a major role in the development of new drilling tools at Hughes and in the improvement of existing tools. As a result, special emphasis has been placed on heat treating, carburizing and atmosphere control equipment in the new Laboratory. These facilities, under the direction of the Metals Group, are used principally for the heat treating and carburizing of experimental products and product parts for laboratory and field testing, and for setting up and maintaining proper controls over metallurgical operations employed in the various production shops in the Hughes plant.

With the Machine Shop to make experimental product parts, together with complete facilities for carburizing, heat treating and other metallurgical processing and the various mechanical and physical testing equipment, valuable technical information can be obtained rapidly and with controlled accuracy.

Technician transferring high temperature pot, loaded with cones, from gas carburizing furnace to slow cooling unit.



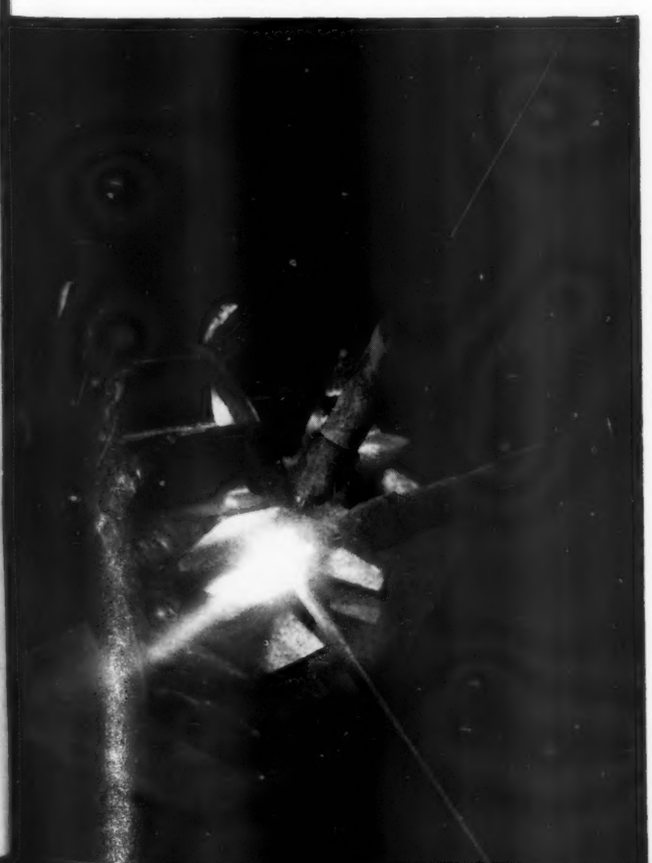
Extent of hard facing and welding facilities is shown in this view of the Welding Laboratory.

Operator applying tube tungsten carbide to the surface of a Hughes "Flash-Weld" tool joint box.

WELDING LABORATORY ADVANCES HARD FACING & WELDING TECHNIQUES

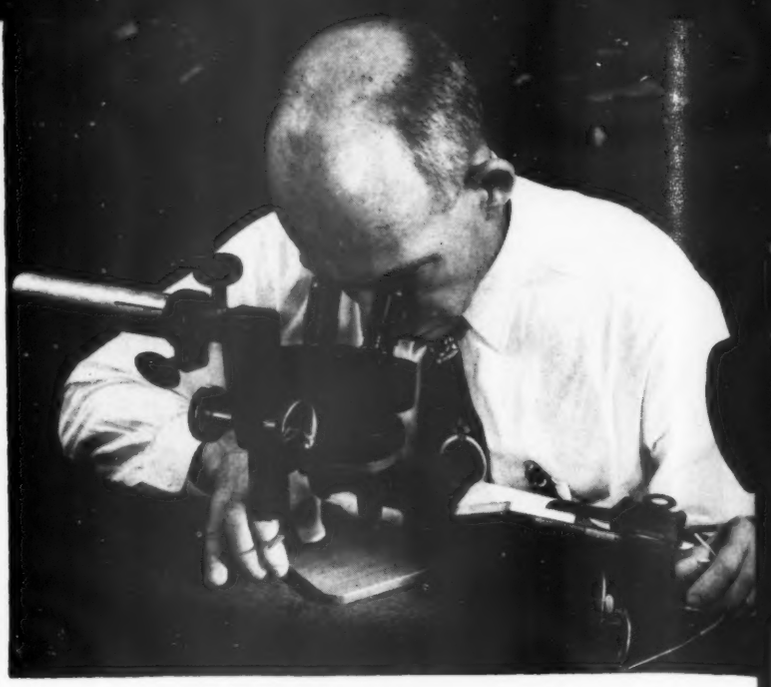
The Hughes Welding Laboratory is equipped to do the hard facing and welding required on experimental tools, conducting investigations of new hard facing materials and techniques, handling the control work on materials and equipment used in shop production welding, hard facing and brazing operations, and carrying on other work normally requiring the use of this type of equipment.

Tube tungsten carbide (Hughesite) is being applied to the teeth of Hughes rock bit cone.

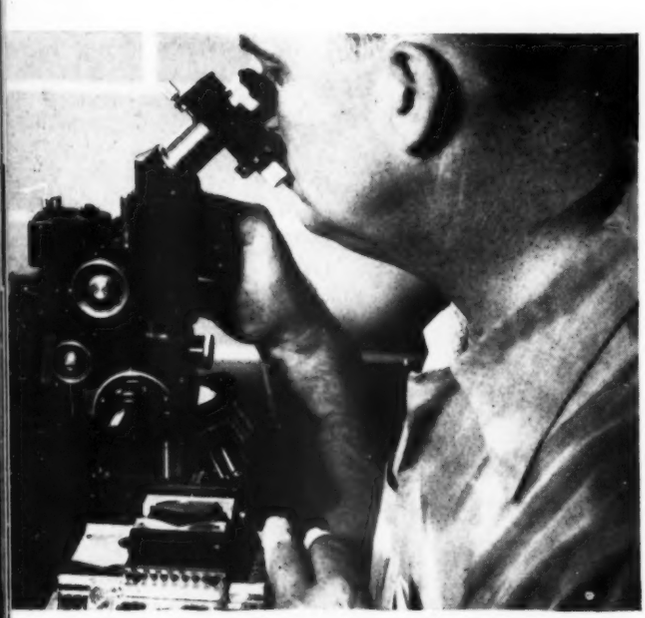


Starting an experimental hard facing job, the welding technician and engineer are selecting required hard facing alloy rods from laboratory-manufactured stock.

Metallurgist prepares for a microstructural examination of a bit tooth section on the metallograph.



The stereoscopic microscope is used to aid visual examination of metal parts where relatively low magnification is desired.



Tukon hardness tester used in measuring Knoop hardness of miscroscopically small areas on finely polished metal specimens.

The hardness of a section of carburized and heat treated Hughes rock bit cone is being measured with a Rockwell hardness tester.

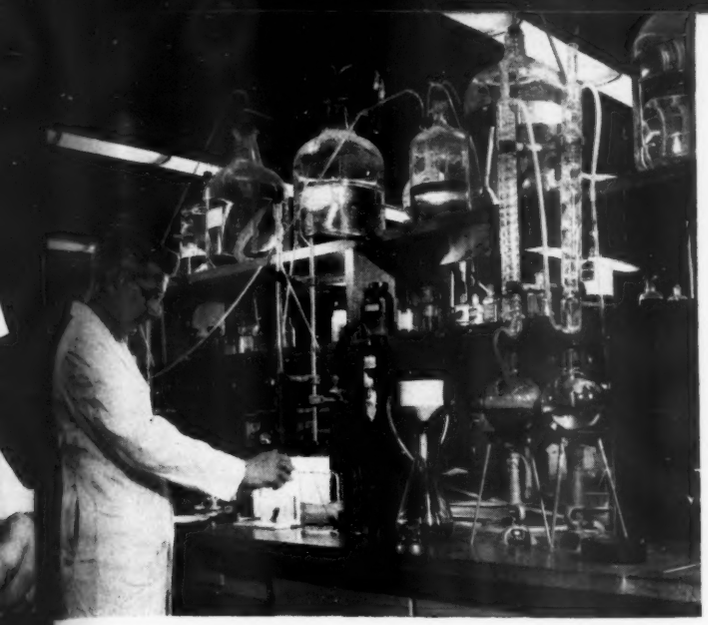
COMPLETELY EQUIPPED METALLOGRAPHIC LABORATORY

The complete array of instruments in the Metallographic Laboratory along with a unique macro-etching installation, designed by the personnel of this group, and a modern, highly efficient dark room arrangement enlarge the scope of work that the Metals Group is prepared to undertake.

The instruments here include latest types and models for the advanced nature and large volume of metallographic work handled by this group. Special emphasis is placed on the importance of hardness measurements and microstructural studies of extremely hard materials (the diamond substitute types) that play such an important role in oil well drilling.

High speed photography is employed to analyze rock bit drilling action and other rapid motion phenomena.

In addition to investigating new materials, and processes, the Hughes Metals Group devotes a substantial part of its time to routine laboratory operations related to metallurgical materials and process controls involved in the Company's manufacturing operations.



Boron analysis is routine step in controlling quality of abrasion-resistant alloys made by Hughes.

The manganese content of a steel sample is being determined in the titration with sodium arsenite.

Combustion type furnaces used for the determination of the carbon content of steel.

General view of the Chemical Laboratory taken during the running of various metal analyses.

CHEMICAL LABORATORY PLAYS IMPORTANT ROLE

The Chemical Laboratory, as set up in the new Research and Engineering Laboratory building, performs a dual role. Its facilities are used to advance the search for new materials to meet the requirements of new products and new uses, and to establish and maintain controls over plant operations.

In the latter capacity, the Laboratory's comprehensive analytical program makes possible the maintenance of high product quality in production carburizing and hardening, as well as the many other metallurgical operations and processes involved in the manufacture of Hughes Tool Company products.

The Laboratory is equipped to handle a wide range of analytical procedures. Among its specialized equipment is the latest type direct-reading spectrometer used for rapid production analyses and for the determination of elements that would be time-consuming under other analytical procedures.

PRODUCT COMPONENTS UNDERGO SEARCHING TESTS IN MECHANICAL TESTING LABORATORY

The Mechanical Testing Section and the Project Engineers assigned to this work are largely concerned with testing product parts or product assemblies under conditions simulating oil well drilling. Many of the Laboratory machines are designed by the group to approximate the conditions that will be imposed on the part or assembly in actual service.

The mechanical testing equipment includes a high capacity torque measuring machine, machines for fatigue testing full-size drill stem connections, machines to test resistance to abrasion, and machines designed and built to test antifriction bearings and plain bearings under variable loading and rotational speeds while being flushed with an abrasive-ladened fluid to simulate drilling mud.

The ultimate objective in these specialized tests is to improve the service life of the product by determining the materials and designs that assure the best results.

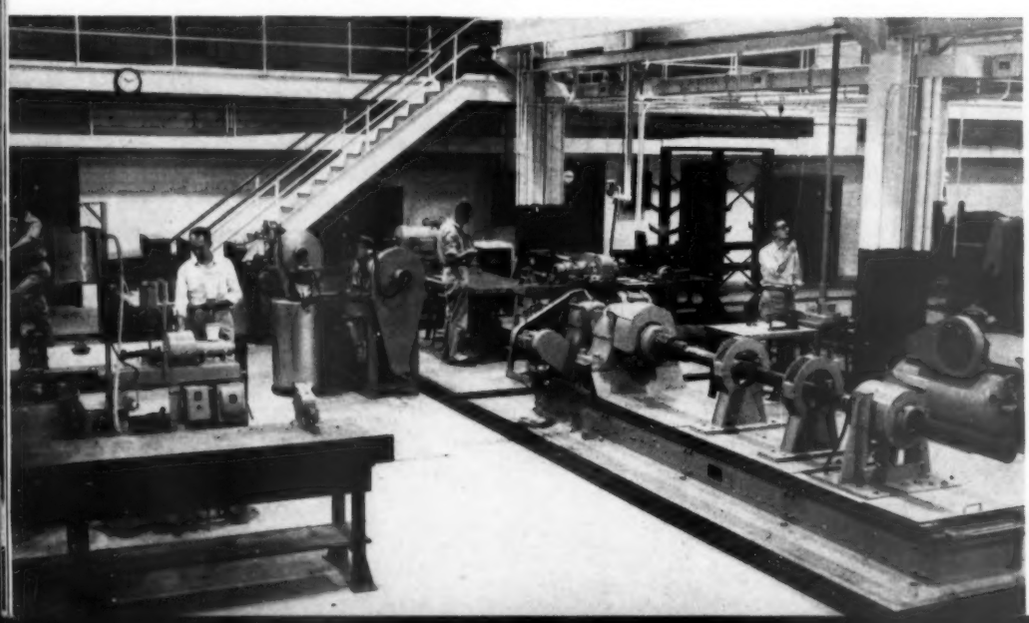
600,000 pound-inch torque measuring machine used in testing drill stem components such as tool joints, drill collars, drill pipe, pin and box connections and tool joint-to-pipe connections.

Rotating cantilever beam type fatigue machine used to test tool joint-to-pipe connections. A bending load is applied by an air cylinder that sets up cycles of reverse bending as the specimen rotates.

Testing the abrasion resistance of the gage surface of a rock bit cutter.

Bit bearing abrasive wear tests indicate the ability of bearings to stand up under severe drilling conditions.

Pictured below is a portion of the area devoted to specialized mechanical testing.



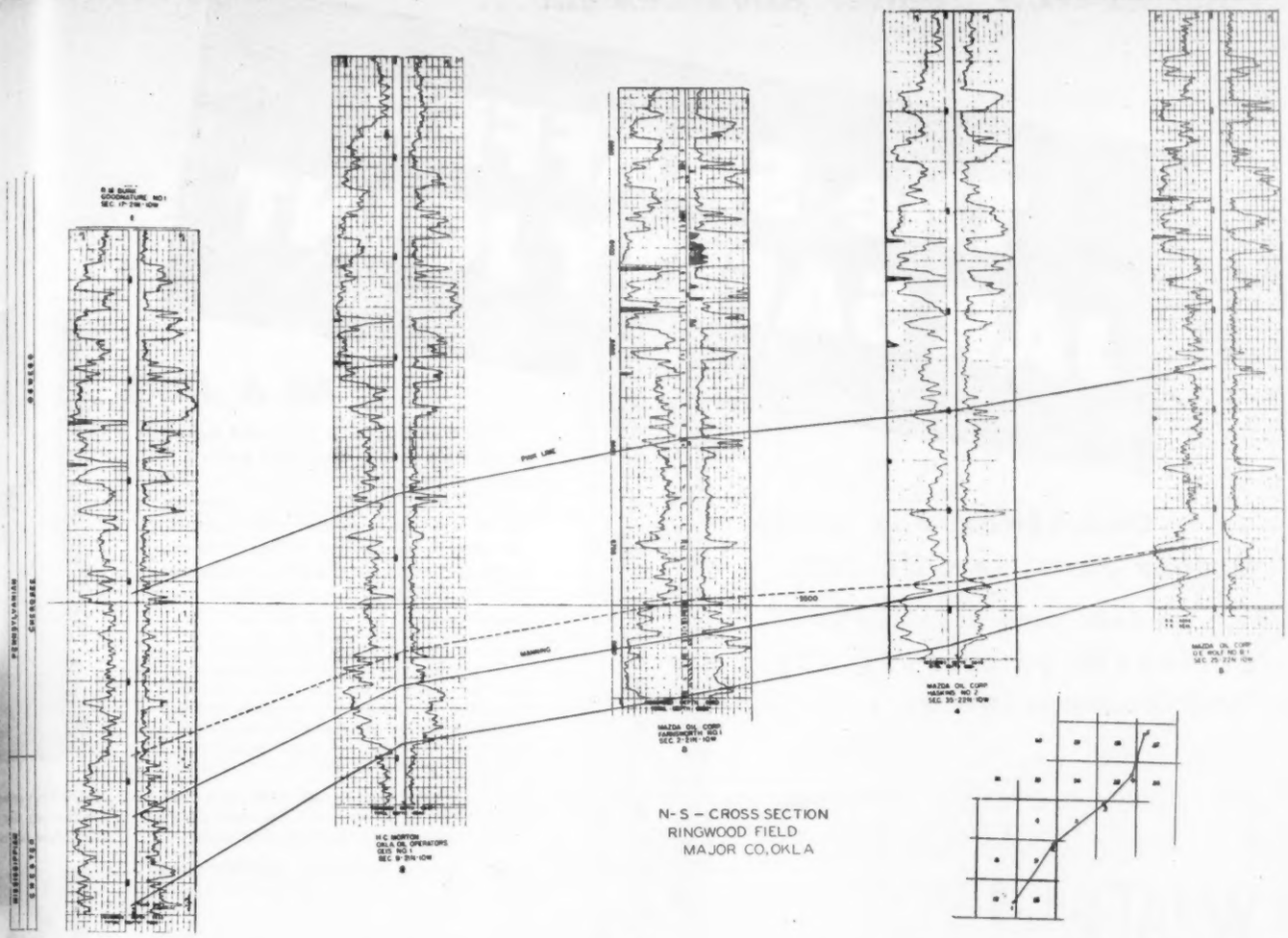


FIG. 1.

Logs by courtesy of Lane-Wells Company.

P 305.

Acidizing Made the Ringwood Pool

Discovered in 1945, the secret of producing the variable Manning sand held back development of 40,000-acre field

HARRY E. LILLIBRIDGE

LYING on the northeastern rim of the Anadarko Basin the large Ringwood pool contains close to 40,000 proved acres; has 228 wells within its limits on established 40-acre spacing; and is the site of the multi-million dollar Warren Petroleum Corporation and Oklahoma Natural Gas Company gas plant.

The Ringwood pool, in Townships 21 and 22 N, Ranges 10 and 11 W, Major County, Oklahoma, was discovered by the Superior Oil Company in 1945. The discovery well, the Superior No. 1 Manning NE NE NW Sec. 27-22N-10W, a very small well, disappointing to both operators and royalty owners, later proved to be very close to the northern limits of production.

The field was slow to develop. After the discovery well was completed late in 1945 it was not until 1947 that the second well was completed, this being the Mazda, Blackstock and Rowland No. 1 Hays, a north offset to the discovery. The No. 1 Hays made considerable gas but little oil. The Mazda No. 1 Wight, one half mile southwest of the discovery, completed in 1948 for 238 bbl, was the first good Manning producer. From such humble beginnings we have today the big sprawling Ringwood field still with thousands of acres of proved but undrilled acreage. (Fig. 2).

The producing horizon is considered

EXCLUSIVE

The Author

Harry E. Lillibridge, who entered consulting work in 1941, was graduated from the University of Oklahoma with a BA degree in geology. During his junior and senior years, and immediately after graduation, he was employed as field geologist for the Oklahoma Geological Survey. In 1925 he began work with the Indian Territory Illuminating Oil Company as field geologist and later was made district geologist with headquarters at Enid, Oklahoma. He remained with the ITIO until it was merged with Cities Service Oil Company. For a number of years Lillibridge was associated with Eason Oil Company as geologist until he resigned in 1941.

Another NEW Shaffer Advancement . . .

The SHAFFER JAR SAFETY JOINT

*** Combines Jar and Safety Joint in ONE tool!**

*** Sets new standards of efficiency, simplicity and compactness!**

Unequalled for Formation Testing, Casing Tests, Diamond Core Drilling, Fishing and similar operations!

WHAT it is!

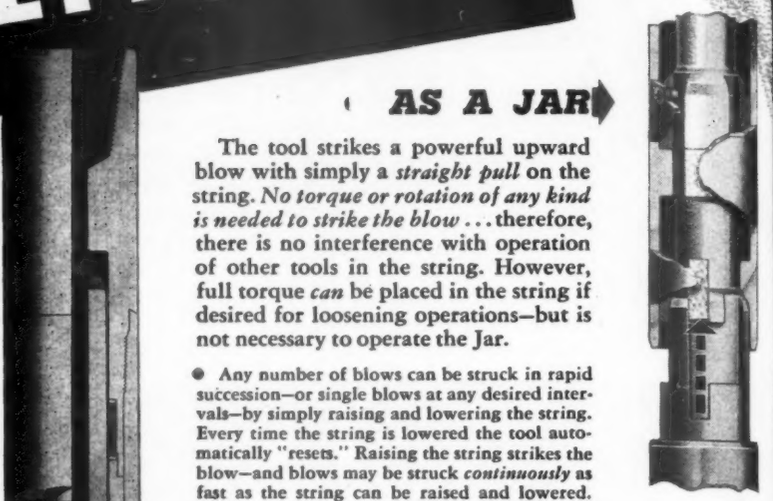
The new Shaffer Jar Safety Joint combines—in ONE compact tool—*both* a straight-pull jar and a quick-releasing Safety Joint. If the stuck string cannot be jarred loose, it can then be disconnected for recovery of everything above the mandrel of the Jar Safety Joint. Later, by simply using the recovered portion of the Jar Safety Joint at the bottom of the run-in string, the recovered string can be reconnected with the stuck portion for subsequent recovery operations. The tool embodies operating principles already field-proven in other Shaffer products—and has been successfully used by leading operators under a wide range of well conditions.

WHY it's better!

The Shaffer Jar Safety Joint not only combines two tools in one—thus saving extra costs and conserving space in the string—but it also provides greater safety and efficiency than assemblies of conventional single-purpose tools. Only a *single* pack-off is required . . . only *one* pin and *one* box . . . only a few simple parts that operate as a coordinated unit in place of many duplicated parts that cause multiple maintenance and operating problems. These and other advantages outlined at right mean safer, more efficient, and more economical operation!

MANY APPLICATIONS

The Shaffer Jar Safety Joint is particularly recommended for use with formation testers, casing shoe tests and on fishing jobs. And, although not designed for heavy, high-speed drilling operations, it is extensively used for diamond core drilling and similar light drilling operations.

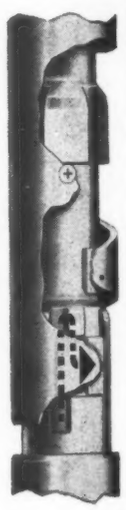


AS A JAR

The tool strikes a powerful upward blow with simply a *straight pull* on the string. *No torque or rotation of any kind is needed to strike the blow* . . . therefore, there is no interference with operation of other tools in the string. However, full torque *can* be placed in the string if desired for loosening operations—but is not necessary to operate the Jar.

- Any number of blows can be struck in rapid succession—or single blows at any desired intervals—by simply raising and lowering the string. Every time the string is lowered the tool automatically "resets." Raising the string strikes the blow—and blows may be struck *continuously* as fast as the string can be raised and lowered.
- Force of the blow is easily adjusted over a range of 10 to 60 tons in 5 ton steps, so that virtually any desired blow can be struck.
- The tripping mechanism does not depend upon friction for operation and strikes a steady, uniform blow.
- All rotational loads are carried by heavy drive keys—not by threads. Since the drive keys are stronger than the run-in string, any amount of torque can be applied to the string—in *either* direction.

Drive keys remain in locking slot as the blow is struck



AS A SAFETY JOINT

. . . this new Shaffer tool is also superior. Since there are no tight-fitting joints or threads to "force," quick release can be effected whenever desired by simply following a few simple operations in proper sequence.

- Only 1/6th turn is needed to release the Safety Joint, eliminating risk of unscrewing other threads in the string.
- Until the Safety Joint is first made ready to release, *any* amount of torque—in *either* direction—can be applied through it without danger of release.
- At any desired time after release, the Safety Joint can be reconnected *in the hole* for further recovery operations.

Rotating drive keys into unlocking slot releases Safety Joint

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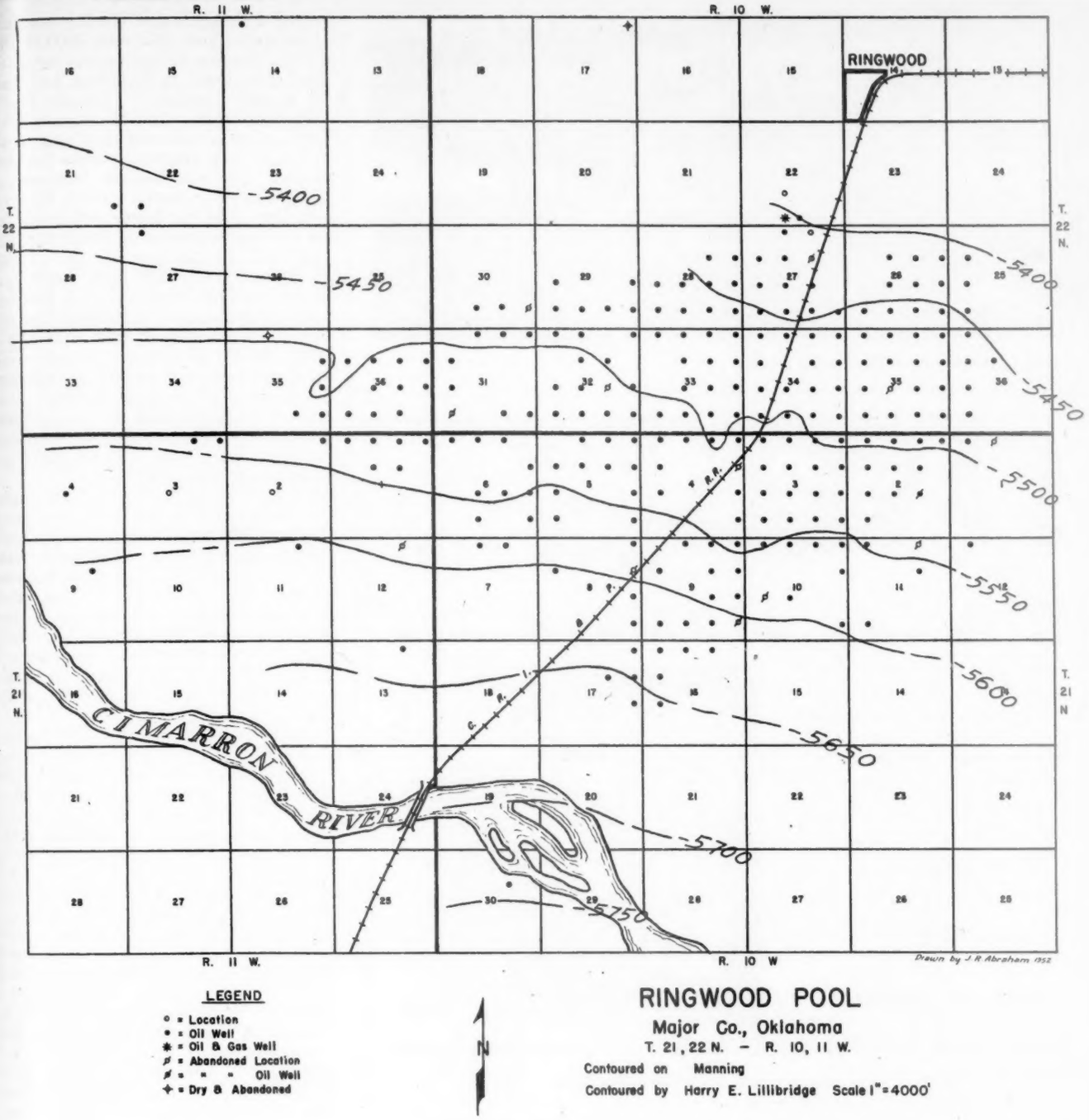

FIG. 2.

to be Chester in age and is overlain in most parts of the area by an unconformity. Both the unconformity and the Manning thicken to the south and southwest. The maximum thickness of Manning, including the unconformity, noted to date is 157 ft. Fig. 1 cutting across the field shows clearly the thickening of both unconformity and Manning to the south and southwest.

The discovery well was carried on down to the Wilcox and then plugged back to test the discovery zone, latter called the "Manning." The well was situated on a seismograph high but to date no anticlinal feature has been noted. Accumulation of oil and gas are entirely due to a stratigraphic trap caused by the pinching out of the Manning to the north. The northern limits of production appear to be very near the northern extent of the Manning.

The Manning is quite variable throughout the field in composition, porosity and the presence or absence of shale breaks. Naturally where either a tight formation is had, a shaley zone or shale break occur, production is poor. Likewise where a good clean thick pay section is found production is well above the average. Note the clean porous pay section in the Mazda No. 1 Farnsworth and the No. 2 Haskins in Fig. 1. These two wells were excellent producers with the No. 1 Farnsworth making up to 150 bbl daily before acidizing. Following acid treatment it flowed as high as 71 bbl an hour. Only a handful of wells produced any oil before acidizing. These wells were mainly located in the northeastern and east central part of the field. The Coronado No. 2 Hutchings NE NE NE Sec 35- 22N- 10W made an excellent production record prior to acidizing. This well began making oil and gas before perforating was completed and flowed steady for over 30 days before operator could run tubing and complete it properly.

Of the 228 wells in the field only a very few could have been completed as good producers without acidizing. In the very early field operations the wells were shot with nitro. Production was

Setting up drilling rig in Anadarko Basin.

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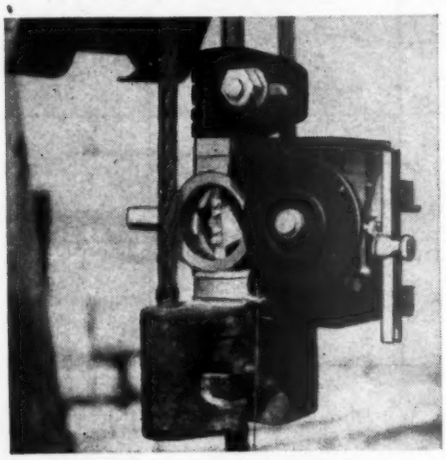

Here's How You Can Cut Burdensome Operating Costs!

MARGINAL WELLS

Lifting costs can be *reduced* by closer control and adjustment of mechanical equipment. In one area alone, 25 wells were transferred from red to black by *operational control* with J-F Dynamometer.

PULLING OF "GREEN PUMPS"

Unnecessary pulling of pumps results in extra labor, material costs and down time. The operations of your pumps may be checked at the surface in a few minutes with a J-F Dynamometer. The test is simple and can be made by the foreman, head roustabout or other personnel.

EQUIPMENT SIZING AND SELECTION

Based on **facts,** accumulated dynamometer information is extremely useful in selection and installation of proper design and size of equipment.

COUNTERBALANCING

About 80% of all wells checked for counterbalance are found to be out of balance in varying degrees. The J-F Dynamometer measures the counterbalance effect at the polished rod. This enables accurate adjustment for normal pumping operation.

SUCKER RODS

Sucker rod failures are caused by load. The J-F Dynamometer records the load of every point in the stroke so that detailed analysis can be made and corrective measures taken.

SIMPLICITY OF OPERATION

The simplicity of operation of the J-F Dynamometer has greatly widened its use for **operational control.** For example, inexperienced personnel, after one day's instruction, can operate the instrument.

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Anadarko Basin

small and mostly gas. The first acidizing jobs in the area used only 1000 to 1500 gal, a fraction of the amount necessary to break down the formation and make it a good commercial producer. Due to the composition of the Manning it would appear that selective acidizing could be used with excellent results but such is not the case. Volume treatment of approximately 20,000 gal 15 per cent regular gives far better results. A few wells were treated with 30,000 to 35,000 gal, and one, the Superior No. 1 Campbell Sec. 2-21N-10W with 50,000 gal. The extra amount of acid used, however, did not appear to be beneficial. The acid treatment is followed with from 240 to 400 bbl oil load. It is interesting to note that the maximum production obtained is on the first treatment and that a second or third treatment does not improve production. Therefore it is necessary to use sufficient acid to assure maximum production on the first try.

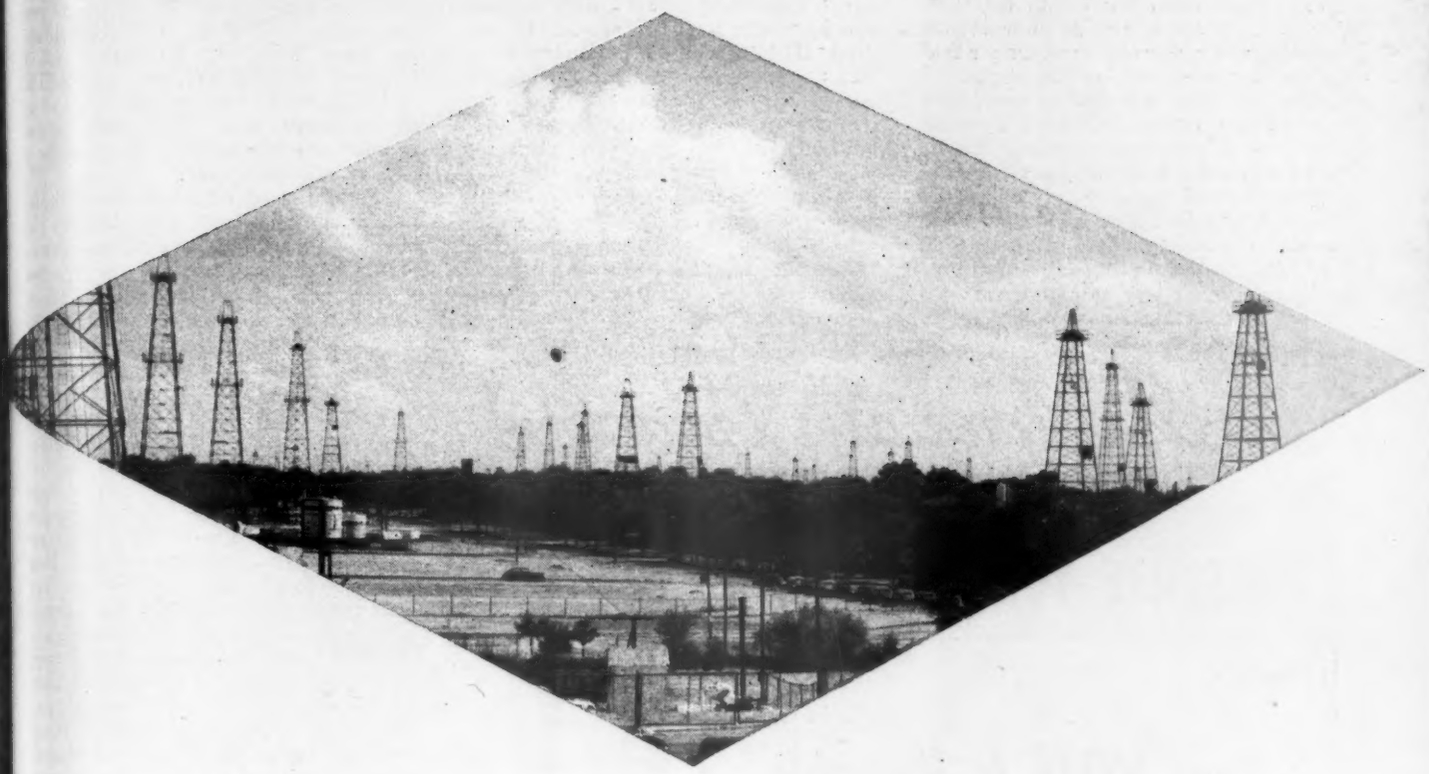
Both Hydrafrac and Stratalift have been tried in the field but without much success. The producing zone is not sufficiently homogeneous to get much value from either method. And, in all fairness, it must be noted that the wells on which these two methods of increasing production were tried, had already been acidized. It is the writer's opinion, however, that the Manning lacks the proper characteristics to use successfully either Hydrafrac or Stratalift.

Drilling practices in the field became standardized soon after 1948. During the first phases of development Superior ran 13⅜-in. surface pipe setting it a little below 500 ft. A 9⅝-in. protective string was then run and cemented at approximately 2400 ft through the anhydrite and salt section found between 1600 and 2400 ft. Mazda and associates ran 10¾-in. surface pipe to approximately 200 ft and did not run a protective string. The practice adopted and followed by most operators in the field, however, now include setting 10¾-in. surface pipe between 300 ft and 400 ft. The scarcity and high cost of pipe has made running a protective string impractical. A 7-in. 23-lb or 5½-in. 17-lb flow string is run and cemented on bottom with from 300 to 600 sacks cement.

Experience has taught that it was best to drill through the Manning and some 40 or 50 ft into the shale below, cement the pipe on bottom, run Lane-Wells radioactivity log, perforate the pay zones in the Manning and then acidize. A drilling-in unit is usually employed to complete the well. Operators do not fear drilling into water for there is no water in the Manning.

Heavy salt contamination makes it necessary to use a salt water mud. Most of the wells start mudding up with a salt water starch preserved mud between 6000 ft and 6200 ft which is just above the Oswego lime series. It is difficult to maintain a good drilling mud in this area. The average mud cost per well will be from $4500 to $5200.

A contractor will average 35 days drilling time from date of spudding in until he reaches total depth. Careful selection of bits according to type of formation to be drilled and good drilling



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practices on the rig has reduced the number of bits to as low as 27 on average 6800 to 6900-ft holes.

The cost of completing a well in the field ranges from $65,000 to $100,000 depending upon depth, completion method, and equipment used. Only a few wells have been put on the pump.

The height of the drilling campaign was reached during 1950-1951 when as many as 35 rigs were running. Mazda Oil Corporation has completed the largest number of wells in the field with Superior second. Superior Oil Company, owning the biggest share of acreage in the field, farmed out numerous spreads, with each spread containing from 400 to 480 acres. Companies taking more than one spread from Superior include, Coronado, Russell Maquire, C. Andrade III, Harold C. Morton, Bolsa Chica, Exploration, George C. Livermore, and Great Western. A number of individuals and operators took one spread. C. Andrade III later sold his producing properties at the reported price of $100,000 per well to Keewanee.

A number of wells have already paid out but it will require several years for most of the wells to pay out. In some parts of the field shows were noted above the Manning. A Lower Pennsylvanian sand, at present called the "Cherokee" sand, extends in a narrow band across the field from east to west. A good light brown stain was noted in

this sand in the Morton No. 1 Cotton NE NE SW Sec. 33-22N-10W.; on drillstem test in the Mazda No. 1 Scannell "B" NE NE NE Sec. 2- 21N- 11W this sand gaged 4,680,320 cu ft gas per day with 5 bbl of 63 gravity distillate per hour. The J. C. Livingston No. 1 Coppock NE NE SW Sec. 4-21N-11W on test has shown up equally as good as the Scannell well. This sand, where present, will undoubtedly prove to be a rich gas-distillate zone.

The spring of 1952 saw the completion of the $6,000,000 gas plant in the heart of the Ringwood field. Operators of the huge gas plant are the Warren Petroleum Corporation and the Oklahoma Natural Gas Company. During the month of August close to 30,000,000 cu ft of gas per day was run through the plant. The monthly total was about 900,000,000 cu ft of gas. During the same period an average of 52,000 gal of gasoline and butane were processed daily.

Champlin Refining Company of Enid is running all of the field production through a 4-in. line to their Enid refinery. The 4-in. line has a 6-mile loop of 6-in. line at each end. The average daily run at present is 4000 bbl. Champlin's pump station at Ringwood has a 50,000-bbl tank and one small tank used for gaging and for an emergency. They are not used for storage. Champlin has handled all of the oil produced at Ringwood and before the pipe line was completed he trucked the oil to the refinery some 30 miles east of Ringwood.

To date no other field similar to Ringwood has been found on the north and northeastern flanks of the Anadarko Basin. There is no reason to believe, however, that this field will not be duplicated elsewhere. It is a question of finding the area in which sedimentation along the flanks will have formed a stratigraphic trap with conditions favorable to the accumulation of oil and gas. Majors and independents alike have realized that the vast area in northwestern Oklahoma will need much study and exploratory work. The convergence and divergence of beds; the rapidly changing stratigraphy within a relatively short distance offers excellent possibilities for future oil discoveries in northwestern Oklahoma and particularly so along the flanks of the Anadarko Basin. * * *

New Productive Area Proved in Greenough Pool

Another productive well has been drilled in the Greenough pool of Beaver County, Oklahoma, in the Anadarko Basin. It is Carter Oil Company and Emby Kaye's No. 3 Sid Sharp, northwest of the field discovery.

On a 4-hr drillstem test at 5799 to 5840, total depth, gas showed in 24 min with tool being pulled for 470 ft of free oil and 90 ft of oil and gas-cut mud. Five and one-half inch casing was cemented at 5799 ft.

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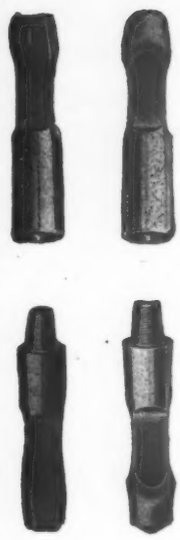

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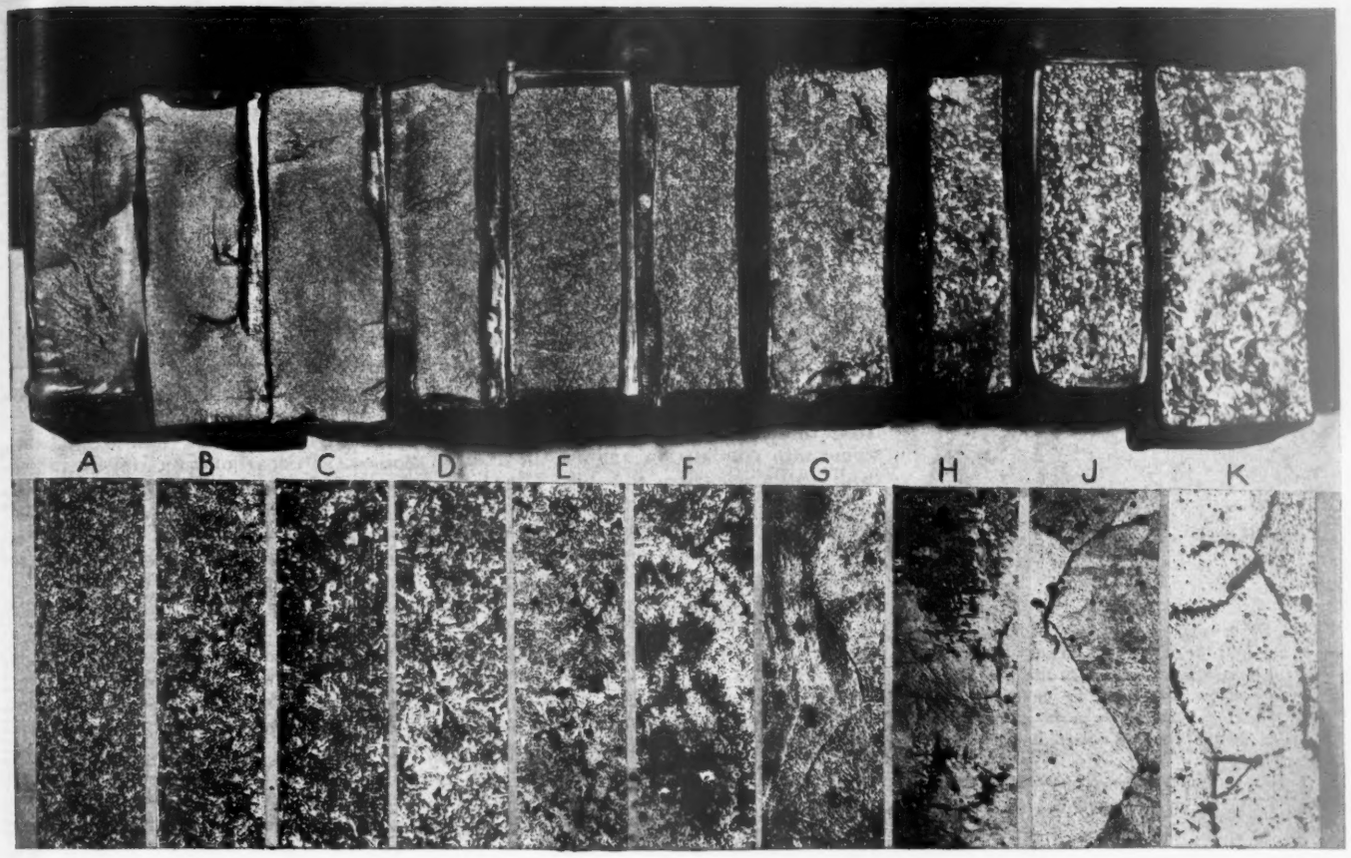

FIG. 2. The above illustrates the change that takes place in the grain structure of steel as a result of heat. The upper row shows natural fractures, the lower shows the corresponding piece magnified. The pair to the extreme left shows the result of heating to the proper hardening temperature and then cooling. Each succeeding pair shows the result of a slightly higher temperature; those to the extreme right show the result of a burning oxidizing temperature.

The Care and Treatment of Cable Tool Bits†

Steps for the proper dressing and hardening of bits that will save considerable cost and delay are given thorough analysis

FERD J. SPANG*

DIFFICULTIES encountered in the standard cable tool method of drilling arise from varied reasons. If one were to list those which lead both directly and indirectly to the most loss in this industry, he would undoubtedly place the cable tool bit at the head of such a list. After placing it there he would, upon analysis of its contributions, find that the cutting or lower end causes the most trouble.

Just why this problem should be left to find its own solution is rather difficult to explain. Improper dressing and hardening of bits add considerable to the cost and delay of cable tool drilling. It is a problem, and a serious one, that should have the cooperative study and support of every one connected with drilling from the tool dresser up to and including the owner.

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*President, Spang and Company, Butler, Pennsylvania.

Because of improper heating, poor dressing and abuse in hardening bits, they sprawl, break and batter, and with continued handling of this kind soon lose all semblance to a proper tool for rapidly drilling a round and straight hole. (See Fig. 1.) Broken pieces left in the hole to be drilled up retard the drilling and add materially to the crookedness of the hole. Needless to say, this all wastes bit steel, adds to the work of the crew and is the direct cause of many jumped pins and other tool breakage.

Ferd J. Spang

It would be hard to estimate the cost of excess wear on tools, particularly joint collars, etc., on the excess wear of wire lines as well as on the inside of casing, caused by crooked holes drilled with improperly handled bits. The size of such losses fades almost into oblivion, however, when compared with the enormous losses through fishing jobs arising directly from this unnecessary condition.

Given a good set of bits, a properly designed forge, and a fair understanding of steel, the regular crew can, without undue effort, reduce these losses to the minimum. The main requirement seems to be the distribution of a knowledge of

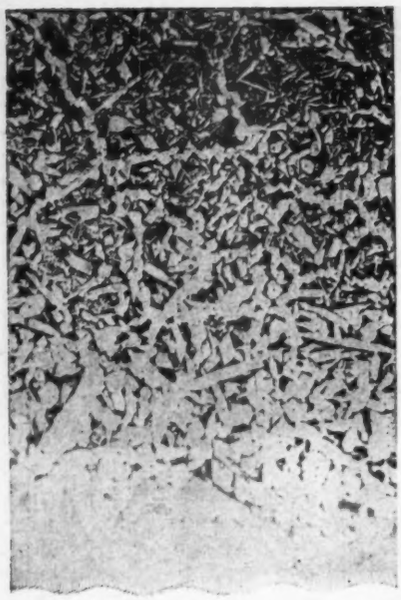


FIG. 3. Decarbonized steel will not harden; the light area on the lower part of the illustration shows the absence of carbon at the steel's surface caused by an oxidizing flame at high temperature. The dark area at the extreme top or inside of the steel is normal for bit steel. (Magnified.)

steel; that is, what steel really is and what happens to it as the result of certain heating, working and cooling. To this should be added the desire to apply such knowledge which, of necessity, must be actuated by the enthusiasm of the manager or owner of the tools.

Correct handling of bits reduces the amount of labor performed by the crew, makes more footage per pound of steel used and per unit of time, and insures a rounder, straighter hole, resulting in less wear and tear on the whole equipment and also reduces the chance of "run" and "pull" casing jobs, all of which will tend toward a lowering of production costs.

Properly made bit steel is a homogeneous composition of iron, carbon, and other ingredients in correct proportion. Its composition and method of manufacture is the successful result of years of study and experience by some of our most able steelmakers. Properly heated, dressed, and hardened, bit steel is both hard and tough. It is fine of grain and will not batter nor break easily, but will wear slowly away.

When heated, steel makes three very important changes, which are expansion, softening and grain re-formation (see Fig. 2), together with other changes of less importance. When cooled it makes but two important changes, these being contraction and hardening (or toughening or annealing). The grain unit makes no material volume change in cooling but may change its shape and cleavage as the result of the rate and method of cooling. This affects the hardness. *These fundamental characteristics must be considered if proper results are to be obtained after heating, dressing and hardening bits.*

Heating is the first thing done to a bit and unquestionably it is the most important. If properly heated it can be properly dressed. *If improperly heated it may be destroyed even before dressing.*

The important thing to start with is a proper forge. It should be so constructed as to allow for complete combustion of the fuel mixture away from the bit and at the same time have the heat evenly distributed around it. It should also be long enough to allow sufficient of the bit to get hot to permit complete stoving or bucking up to back up the wearing surfaces.

The fuel entrance should be well below the bit (10 to 12 in.) and directed from the front of the forge to strike and come into combustion against the rear wall, fully clearing the bit. The bit should not be laid in, on, nor covered with either mud or ashes while heating as this causes cross-wise cracks to develop in the blade at the heat stoppage point.

Even more important is the composition of and completeness of the mixture of fuel and air. *A surplus of air or a portion of unmixed air will damage the steel,* the degree of damage depending upon the final temperature, the time the bit is in the furnace at heat, and the amount of the excess air. *Under no circumstances should the blast strike or come into combustion on any part of the bit.*

The determining factor in the hardness and usefulness of the bit steel is carbon, together with its proper minute distribution. Carbon is a non-metallic element that when alloyed with iron forms the hardness grains or crystals of the steel. Carbon is attracted to and readily joins with oxygen, the attraction becoming greater at higher temperatures. Therefore, any surplus air which

Editor's Note: This article first appeared in the mid-year 1930 issue of *The Petroleum Engineer*. Since that time it has appeared in various trade papers published both in the United States and abroad. It has been revised and appears again because of the value of the information it contains to the petroleum industry. It is copyrighted by Ferd J. Spang and can only be used with his permission.

contains oxygen in a hot furnace becomes a decarbonizing agent which draws from the surface of the hot steel considerable of its carbon and the steel becomes less hardenable. As carbon is the element which causes the grain to form, it follows that the escape of carbon results in a lesser number of the grains which are left in the steel mass to be hardened. (See Fig. 3.) Thus it is essential that only as much air be introduced with the fuel as will be completely consumed by it. A small surplus of fuel in the mixture retards the rate of heating, insures complete consumption of the oxygen and is an aid in preventing the burning of the steel. *It is seldom that steel is burned by a mixture which is rich in fuel unless the bit is left in the fire entirely too long.*

A thin mixture oxidizes the steel and forms heavy scale on it as well as decarbonizes it. This excessively reduces the size of the blade above the wearing surface. Therefore it requires more of an upset to get it dressed out to gage. Such a condition leaves the wearing surface with a weakened support and is partially responsible for breakage. Be-

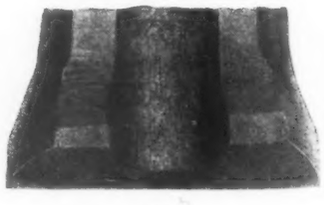
FIG. 4.

4A

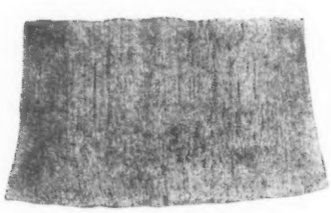
4B

Fig. 4A shows the lapped over wearing surface o fa bit caused by quick and shallow or short heating and light sledge or ram blows. Just above the wearing surface the bit is oxidized under size from using a thin fuel mixture. Fig. 4B is a deep center section cut from a similar bit and deep etched to show the work lines caused by such treatment.

FIG. 5.



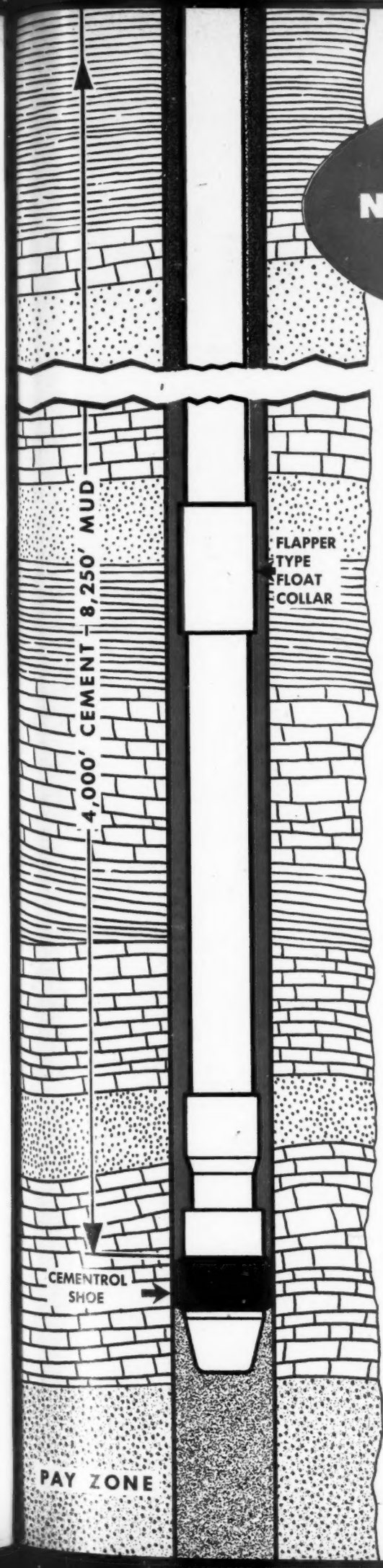
5A



5B

Fig. 5A shows a correctly dressed bit. Fig. 5B is a center section cut from a similar bit and deep etched to show the work lines caused by correct heating and up-setting. Notice that the work lines are straight and evenly up-set. Slow, thorough heating of sufficient depth to permit up-setting by well-directed, heavy blows is evident. Such care insures adequate support for the wearing surface.

SET AT 12,250 FEET
NO CEMENT CONTAMINATION OF PAY !



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Top: Cementrol Shoe in Pack-off Position

Bottom: Flapper Type Float Collar

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The Cementrol Shoe, shown above in the "pack-off" position provides an annular pack-off and an internal bridge that prevent the downward passage of slurry. In the well illustrated, 4000 feet of cement and 8250 feet of mud were successfully kept from contact with the producing zone. The Flapper-Type Float Collar used in conjunction with the Shoe permits passage of the bridging ball which actuates the Cementrol Shoe and prevents return flow of the slurry.

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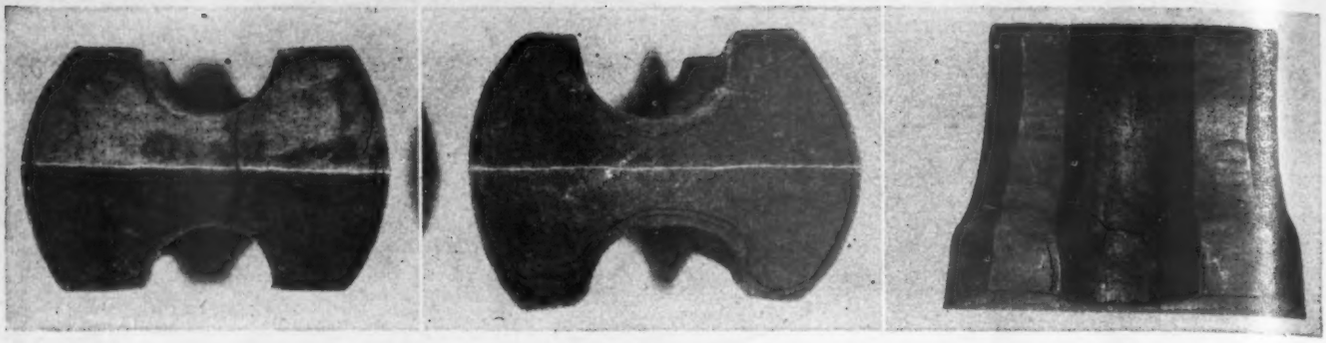

FIG. 6. Raising the temperature of the surface of the steel at a rate faster than it can transmit the heat by conductivity to the steel in the center causes the surface to expand faster than the center follows; the result is a rupture or shell. Split water courses are often caused in the same way.

cause of the smallness of the blade the wearing surface is shorter than need be, resulting in the bit wearing quickly out of gage. (See Figs. 4A and 4B.)

A proper heating mixture is one that will burn with some flame color at the openings of the forge. This flame should be tipped with light orange and may produce a slight amount of smoke and odor. The combustion should be neither fully blue nor completely transparent. A roaring fire indicates an explosive combustion that is of a mixture too thin for continuous free burning.

The rate of heating and the final temperature are very important items to be considered. The colder the steel is, the more brittle it is, and the slower it conducts heat from the surface to the interior. For these two important reasons the initial rate of heating should be slow and the mixture very rich to eliminate cracks or ruptures in the bit and presaturate it with heat in order that it may be in condition to more rapidly convey the faster heat, which is to be absorbed into the body of the bit.

Quick heating of the surface of the cold steel expands and lengthens it and tends to pull it away from the center, in this way causing a rupture. (See Fig. 6.) *A thin mixture goes into combustion only when it strikes some object.* If this object be the bit, it tends to combust on the sharp projections of the corners of the bit, heating them much quicker than the body of the bit, causing them to shell off or break off, or at least to start cracks .(See Fig. 7.) These cracks may not be visible until quenching, or possibly not until further use of the bit, but there can be no doubt of their presence. A *thin mixture* will also burn the corners and point of the bit as the steel cannot transmit the heat absorbed by the corners and points as fast as it is accumulated. Such a heat may spot-burn points on the face of a bit and later cause it to break in quenching. (See Plates H, J, and L, Fig. 1.) To be fully safe always have a sunflower of flame around the forge opening.

The bit should be slowly pre-heated in a *rich mixture* until it is up to uniform dark red color. The blast should then be increased and the bit heated faster until ready to dress. In the forging and working of steel mills and forge shops, it has long been the practice not to heat steel such as bits are made of, at a rate including the pre-heat period, faster than one-half inch per hour when measured from the center of the greatest section to its nearest surface. By this rule a bit (20-in.), as shown in Fig. 8 would measure 3-in. to the center of the mass from its nearest surface, and hence requires six hours for a proper heat. The most of this time should be spent in pre-heating the bit in a *rich fuel mixture* until the bit comes up to a *dark cherry red* as heat below this point will neither decarbonize the steel nor coarsen its grain. Heating time for larger or smaller bits can be computed in this manner. The need of this practice seems to be neither fully realized nor followed in the industry; as a result, in order to get the bit soft enough to work at all, the surface is excessively overheated while the interior is very much underheated.

A surface or wash heat permits only the surface to move when struck with the ram or sledge. Thus the soft surface slips over the harder core and washes out over it (spreading) to get sufficient wearing surface. The wearing surface, therefore, is composed of old, cracked, torn and decarbonized steel that has been many times reheated and sometimes even burned. These conditions cause buckles and cracks on both the wearing surface and in the heel above it. Such a wearing surface will drill but little hole before it wears and breaks out of gage.

Adequate time in preheating and final heating will put the core, as well as the surface, in a good plastic condition and it need not be overheated. *A rich fuel mixture heats slowly and thoroughly.*

A properly heated bit will be easily and properly upset instead of "riveted," thereby bringing out to the wearing surface new sound steel to replace that previously worn away, and at the same time it swells the body above the wearing surface, lengthening it and giving it a real support. Such a bit will unquestionably give much more service, will spawl off much less, is not likely to break off in large pieces and will drill a rounder, straighter hole. For surface conditions resulting from proper and improper heating and stoving, see Figs. 4A and 5A. For interior flow or work lines, see 4B and 5B.

The overheating of steel is one of the most prevalent and serious causes of troubles with bits. It would be rather difficult to define the line between overheated and burned steel. Fig. 1, plates J and L, show slight burns. Fig. 1, plates A, B, and O, show destructive burns.

As previously stated, *overheating of steel in a rich flame is not nearly so dangerous as in a lean or oxidizing flame.*

If overheated only, or slightly oversaturated with heat, it has developed a very large unbalanced grain structure,

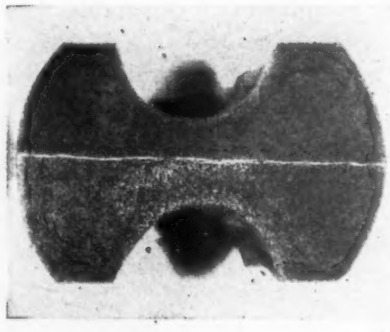

FIG. 7. Thin mixtures go into incandescent combustion on sharp corners. Such points quickly become excessively hot and as there is no other heat of consequence on the balance of the bit, the inequality causes ruptures or shells.

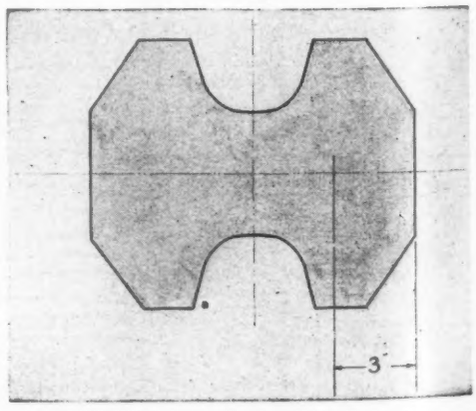

FIG. 8. Measure from the center of one side of the bit to the surface in inches, then multiply by two, which gives the number of hours necessary to produce a correct heat for dressing bits.

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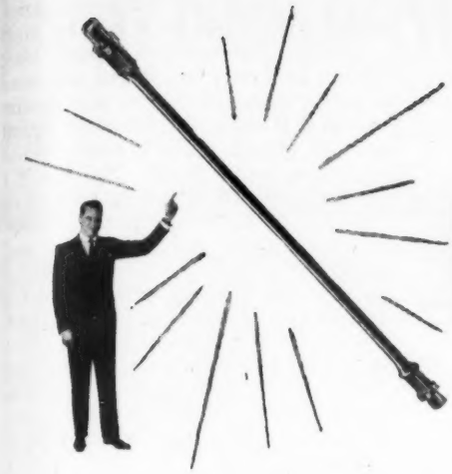

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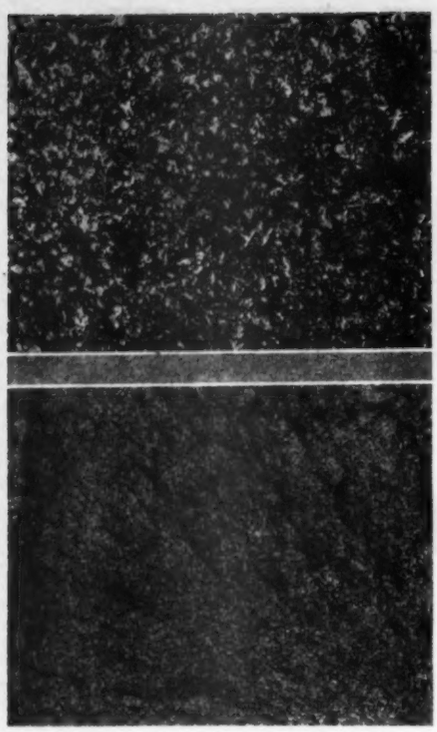

FIG. 9. Results of reclaiming overheated steel. Above, magnified; below, actual break.

in which case it does not always follow that it has been rendered useless, but it may become so if shocked by work, and even if not shocked unless proper steps are taken to recondition it.

Forged in, the condition caused by overheating, may result in ruptures that make it useless. Overheated steel, when not ruptured from work or oxidation (burning), should be immediately allowed to cool. If the overheated steel is forged in such condition, there will be danger of bursting it.

When cooled below color, it should be heated slowly to a cherry red, then allowed to cool below color in the air, after which it may be reheated for dressing. When heated for dressing, the cutting faces, edges and corners, etc., should be trimmed off so as to get below the decarbonized, porous and burned surface, after which it may be dressed.

As previously stated, high heat causes grain growth and consequently the higher the heat the greater the grain size, the thicker the grain boundaries, and the harder it is to again reduce them to correctness. The foregoing procedure is a simple method of correcting the grain size and absorbing the grain boundaries. See Fig. 9, which shows the results obtained by this method.

As yet there is no way of reclaiming burned steel except to remelt it into new steel. If slightly surface burned (see Fig. 1, plates J and L), it may be "pared off" by taking a shaving off deep enough to reach the bottom of the ruptures or pock marks. If very extensively burned, however, (see Fig. 1, plates A, B, and O), the whole end must be cut off, using particular care not to again burn the bit when heating to cut it off. For burned steel micro-photographs see Fig. 10, and also Fig. 2, plate K.

It may be stated safely that surface burns or scalds result from the quick heating of bits in thin high temperature flames while internal burns result from long exposure and consequent excessive heat saturation from either thin or rich fuel mixtures.

The reaction of the tool dresser and driller to any suggestion of the proper heat to use to dress a bit seems to center on the fact that he has no temperature-indicating instrument to tell him when the proper heat is reached. In this connection it is well for those interested to know that the use of heat-indicating instruments in forge shops for designating proper forging temperature is quite rare. Most all forge men depend on their vision and the looks of the steel, taking into consideration the combustion conditions within the furnace. Constant practice and visual comparatives, of course, aid them in their work, consequently it is very rare that steel is spoiled by them by either overheating or burning.

There are several ways of telling the proper forging heat, but perhaps the one most easily adapted to men who use it but intermittently is by noting the condition of the scale. In this method it is most important to see that the fuel mixture is of right proportions; if so, the scale will form slowly, will be relatively thin, and at the proper forging temperature it should raise in small blisters. These blisters quickly heat to incandescence and appear as small spots which are lighter in color than the scale which has not raised and this remains the same color as the steel. As soon as they appear, the bit should be removed from the forge and dressed.

Scale is a natural blanket-like protection to the steel; when it loosens and raises, it is a danger signal. Therefore, under no circumstances should the bit be left in the fire until the incandescent spots enlarge or until a considerable area becomes incandescent and the scale starts to run as slag, showing "bald" or scaleless spots. This allows both carbon and iron (yellowjackets) to freely escape and burns the steel.

If sufficient time is allowed to preheat the steel to a dark red it may then be brought quickly to a forging heat but a melting heat will not be needed to make the bit fully plastic.

If the heat is right the scale will fall freely away as the steel is worked and it should have a fine-grained, satin-appearing texture much like an eggshell. If the scale sticks to the steel, it was too hot, or the fuel mixture was too lean. If too hot, the scale will be thicker and more porous. If the mixture was too thin, its exterior will be spongy, dull and dry-looking and the side next to the steel will be very porous.

The question is often asked as to what to do in case a heat is ready and the dressing cannot be done immediately. This should be avoided by careful planning but due to the unusual conditions that may arise in drilling it will sometimes happen, and when it does there is only one safe thing to do and that is to shut off the blast but leave some fuel turned on so it burns in the furnace to consume the air and prevent scaling and de-carbonization which rapidly takes place with hot steel in free air. Burning fuel without blast will not heat very much and will tend to carbonize rather than to decarbonize the steel. It will not, however, retard the grain growth which is very rapid at the forging temperature. (See Fig. 2.) If borax is available, it may be used as a coating to advantage in such emergencies as it will reduce the heat and protect the steel.

The actual dressing of bits is not a question to be considered here, as those in the field know from actual experience the shape and type of dressing best suited to their ideals and needs. A few things, however, that affect the action and use of the steel may well be brought to their attention.

The blows of the sledge or ram should be heavy and directed fairly and accurately at the face of the bit in order that an actual stoving up action may take place. Cornerwise and light blows (see Fig. 1, plates E, F, G, K, and L) aimed at spreading or washing of the surface of the steel toward the wearing surface of the bit, tends to pull and tear it apart. This causes split water courses, ruptures and laps or cold shuts to form, and does not give a backing for wearing surface. For surface condition and interior flow lines of improperly heated and stoved bits, see Fig. 4A and 4B. For those of properly heated and stoved bits, see Fig. 5A and 5B.

The overflow of steel in the watercourse may be reduced by careful dressing and keeping it down as formed. When a surplus does accumulate, however, it should be removed with a gouge instead of a splitting chisel and all nicks

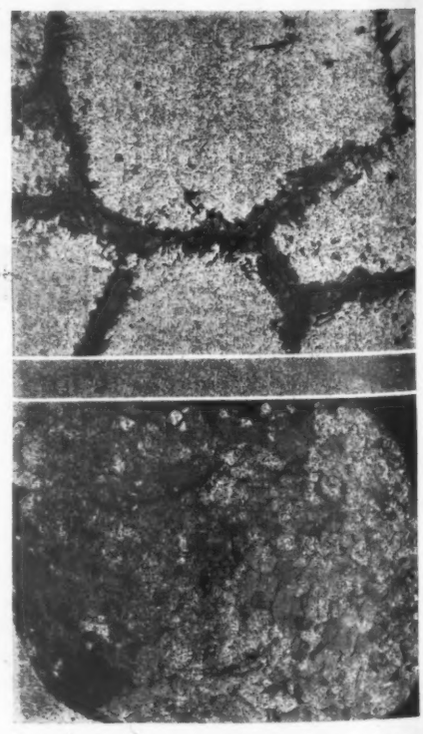

FIG. 10. Burned steel. Above, magnified; below, actual break.

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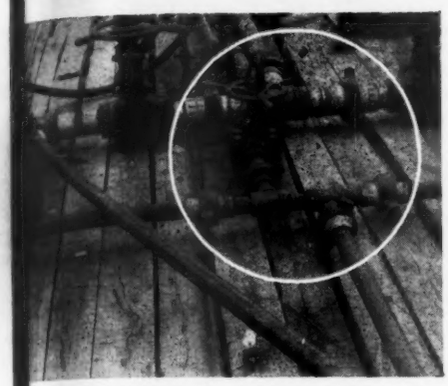
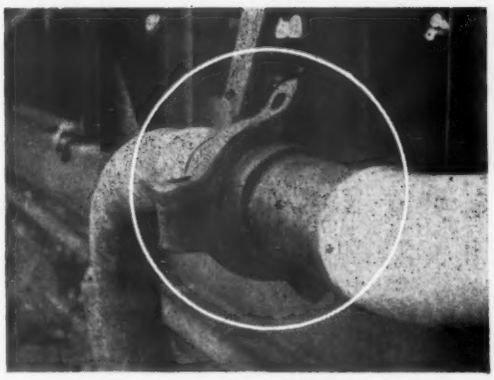
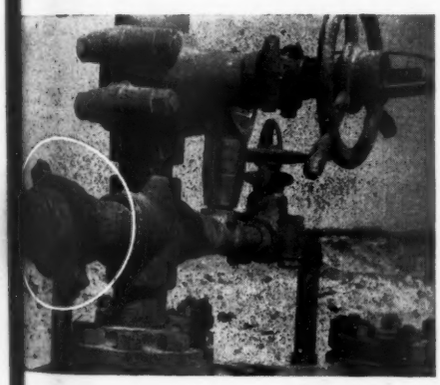


WECO Fig. 600 Unions on a mud line manifold. "Standardize with WECO" for this service to save time and trouble.



This WECO FIG. 100 on a mud return line can be made up with hammer or bar.



Four inch FIG. 602 on pump discharge withstands severe vibration and pulsation without leaking.

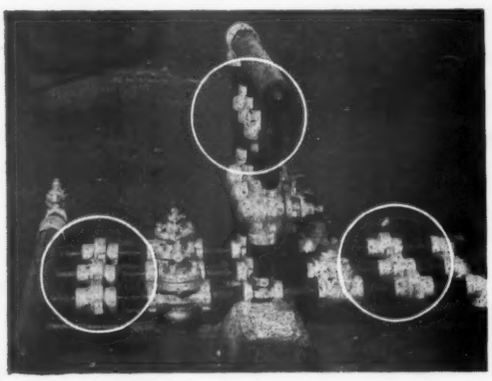


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FIG 100
1000 p.s.i. TEST
SIZES: 2", 2½", 3", 4", 6", 8"

FIG. 200
2000 p.s.i. TEST
SIZES: 1", 1¼", 1½", 2", 2½"
3", 4", 6", 8"

FIG 400
4000 p.s.i. TEST
SIZES: 2", 2½", 3", 4", 5½" O.D.,
6", 7" O.D., 8", 10"

FIG 600
6000 p.s.i. TEST
SIZES: 1", 1½", 2", 2½", 3", 4"

FIG. 602
6000 p.s.i. TEST
SIZES: 1", 1½", 2", 3", 4"

FIG 1502
15,000 p.s.i. TEST
SIZES: 2", 2½", 3"

or cracks should be eliminated, otherwise they will develop into fractures. (See Fig. 1, Plate C.) *The water-course may safely be trimmed with the oxy-acetylene cutting torch provided the bit has been sufficiently pre-heated to show color.*

Seams should always be fully removed. If there is an advanced side, it should be trimmed back even with the short side so that the cutting edge remains square. The corners should be full to gage and the points shy or slightly dubbed. Finally the corners and edges should not be pounded when the steel is black as this tends to cause cold slips, resulting in water cracks and spawling.

A properly dressed bit, from the standpoint of hardening, is one that has *not* been unduly strained by working at a poor heat, one that is smooth and free from defects such as laps, cold shuts, cracks, chisel marks, etc., and one that does not have a hollow center or face except when accurately machine dressed.

Following the dressing, the hardening must take place. It is customary for some operators to either quench the bit from the anvil or to immediately reheat it and quench. Both of these processes are decidedly wrong, the latter perhaps much worse than the former.

It has been previously stated that one of the characteristic things about steel is that when heated above a cherry red it is subject to grain growth (see Fig. 2), and that the grain size does not change when cooling. Thus the heat necessary to dress a bit causes it to have a coarse grain and even though it is quenched from a lower heat it will still have a make-up of coarse grains. The only way that the grain structure of steel may be refined to the desirable size is to allow it to cool down through the transformation point to black and then reheat it to a cherry red color, which forms the desired grain structure.

The transformation point where the re-formation of grain structure takes place is known as the critical temperature. Below this temperature, no perceptible changes take place in the grain unit. As this temperature is passed when heating steel, the minute particles or units are said to go into solution; that is, they separate into the smallest units possible. (See Plate A, Fig. 2.) *If quenched from this or a slightly higher temperature, an ideal structure is the result.* If heated to still higher temperatures, however, these units attract each other, resulting in the formation of larger units and thicker grain boundaries. (See Plates B to J, Fig. 2.)

As the finer grain structure is both harder and stronger, *it naturally follows that the lowest quenching temperatures that will produce thorough hardness is the one that will yield the most satisfactory results.* It also follows that a bit that has been quenched directly from the anvil or reheated before allowing to cool below the critical temperature (i.e., transformation point), will carry with it the grain structure formed by the highest preceding heat used to dress it.

The important thing in hardening bits is the temperature, how it is approached, and the thoroughness of the heat. The flame used for heating the steel should

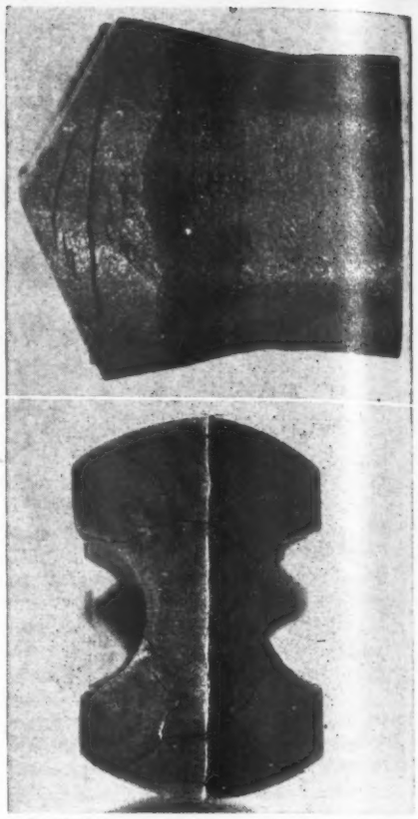

FIG. 11. Bits quenched from uneven heats have uneven shrinkage, causing cracks which quickly progress, causing much breakage.

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be fairly rich and not too voluminous in order that the bit be heated slowly and evenly. To determine the temperature nothing seems practical in the field but a visual interpretation from color. This, at its best, is rather uncertain, but with some little effort will prove sufficiently accurate to give much better results than are usually obtained. One must remember that the color is caused by heat, but the reaction on the eye varies with the light, the humidity, and color of surroundings. The pupils in the eyes are in much different condition in the sunlight at noon than they are at midnight in the dark. Then, too, the reflection of an electric, a gas or an oil light on hot steel will in each case make the color of it look somewhat different. If one takes such things into consideration, he can come fairly close to estimating the temperature of steel after he has accustomed himself to the proper color under such conditions for that temperature.

On a color basis the transformation has taken place when these colors show in the bit:

(a) A light cherry red in the dark at night.
(b) A medium cherry red in the early morning, or during dark, hazy days, or after the sunset of a bright, clear day.
(c) A dark cherry red when protected by shade on a sunny day or in the presence of bright artificial lights.
(d) A very black red in the open on a clear sunny day.

There is another method that may be used very satisfactorily to ascertain that the heat has passed the transformation point. It consists of suspending a small horseshoe magnet from a rod by a brass or copper wire. If the steel has transformed, it will not hold the magnet. Consequently the bit should be quenched shortly after the magnet ceases to hold to the steel.

Still another method is to observe the formation of scale. As the scale formed below the transformation point is negligible, it is evident that any steel that is visibly in the process of forming scale is above the critical temperature.

It must be borne in mind that these latter two processes may only be used to check that the steel has passed through the critical temperature and neither of them in any way checks high temperatures. In the case of scaling, one can note the thickness. If light scale is visible, one may assume that the critical temperature has been reached. If it is very thick, it is evident that it has been considerably exceeded.

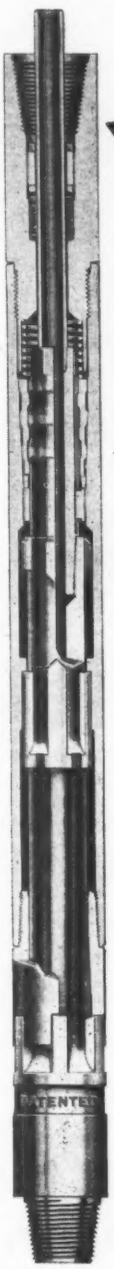
Quenching may be done immediately after removing from the furnace, but before removing it is well to shut off the blast for a short time to allow the heat a good opportunity to even up. Unless a little time is allowed for the heat to equalize, the projecting corners may be too hot for quenching and, on account of the different shrinkage rates from different temperatures, they are liable to shell off when quenched.

The result of such quenching is shown in Fig. 11. The ordinary slack tub, provided it has sufficient volume, is quite satisfactory for quenching; however, it is well to either drain off the water or remove the bit when the blade just above the water line has cooled until it is warm to the touch. In other words, *it is not desirable to let a bit become stone cold in water, as hardness cracks are caused in that way*. For large bits a circulating system is desirable.

When considerable of the same size hole is drilled and particularly when the drilling is difficult, the dressing and hardening of bits can be much simplified and delays avoided by putting into use three instead of two bits per set. By so doing sufficient time can be given to the heating and cooling, and if planned, a fresh bit will always be available.

Bits drill good holes or drill bad ones, straight ones or crooked ones, drill fast or slow, are expensive or economical, either as a result of care or of misuse. If in the future, as in the past, they are looked upon as a necessary evil, they will continue to be the source of a great loss. If, on the other hand, they will be used and cared for as one of the most important articles in use to reduce the cost of drilling should be cared for, one can look for and expect such a reduction.

It is the duty of all those responsible in any way for their use to do their full share in gaining such benefits for the drilling industry. * * *



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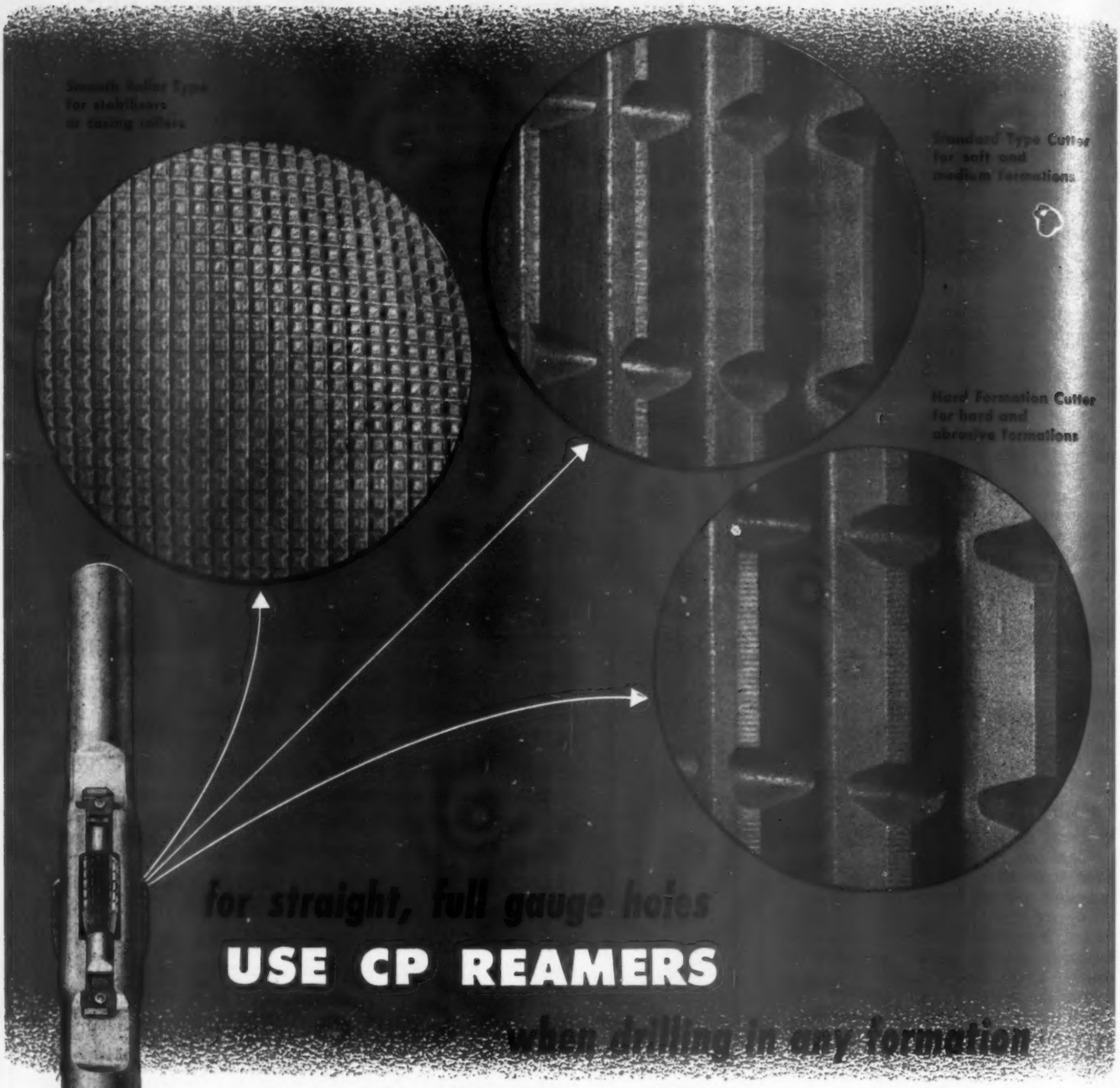

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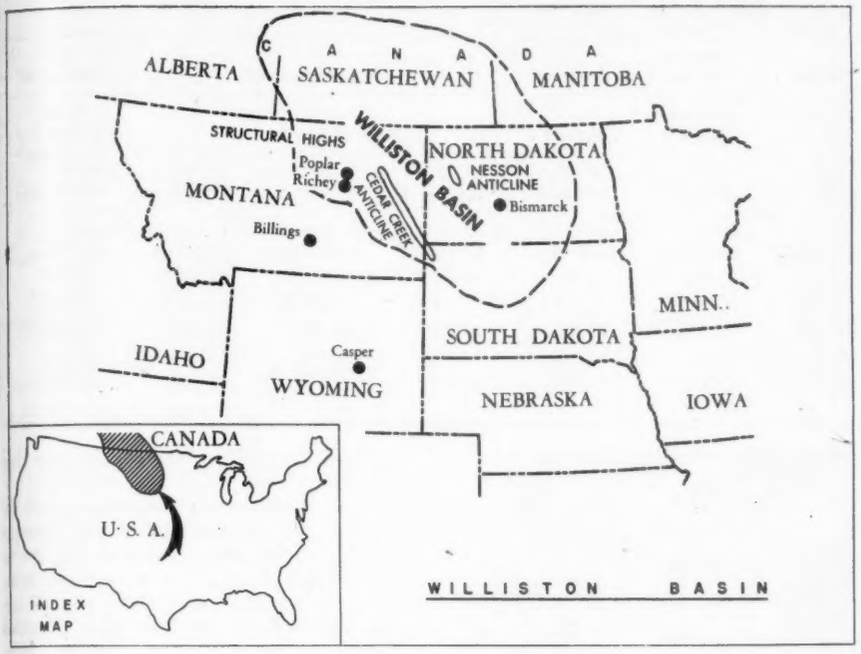


FIG. 1.

Drilling depths in the Williston Basin vary between 5000 and 13,000 ft. The basin covers 76,000,000 acres.

The Lid Is Off the Williston Basin!

Limestone production is sought in the 120,000-square mile basin — How to complete? That is the question

JACK MENNEER*

The first commercial oil was produced in the Williston Basin in 1951 from Amerada Petroleum Company's discovery well in the Beaver Lodge field, North Dakota. Exploration activity has now reached an all time high.

The basin has a tentatively estimated area of 76,000,000 acres extending over parts of Montana, North and South Dakota, and into the Provinces of Saskatchewan and Manitoba in Canada. The basin has widely dispersed activities.

Current production is from limestone. Because of the variable and peculiar characteristics of the reservoirs a patterned completion technique is not presently possible. The exclusion of water is also a problem. An operator has to study carefully the well costs when a completion program is under consideration.

Cost figures are given for a well drilled on the Poplar anticline. The basin is in the initial stages of oil development, and the possibilities are thought to be good.

*Editor Drilling and Producing.

DISCOVERY of oil by the Amerada Company in 1951 in the North Dakota field of Beaver Lodge gave support to the existing theory concerning the possible hydrocarbon accumulation in the Williston Basin. Following the Beaver Lodge, Shell Oil Company had initial production in its Richey well a 100 miles away in Montana. An oil pattern was developing and substantiating evidence was now available that the extensive basin had petroleum in commercial quantities. The discovery oil well drilled by Socony in lower Saskatchewan, Canada, at mid-year is another probable addition to the list.

The Williston Basin covers 120,000 square miles (76,000,000 acres) in the states of Montana, North and South Dakota, and in the Provinces of Saskatchewan and Manitoba, and perhaps Alberta, in Canada. (See Fig. 1). The basin is a structural depression that lies between the Rocky Mountains in the west, and the Canadian Shield (igneous) in the northeast. Formations in the basin range from pre-Cambrian to Tertiary and the center is covered with glacial drift. The exact areal extent of the basin is far from being assessed as yet, and the oil possibilities are similarly indeterminable. In point of fact much exploration and development are necessary before any attempt can be made in determining the limits of the basin and an idea as regards the estimated reserves.

EXCLUSIVE

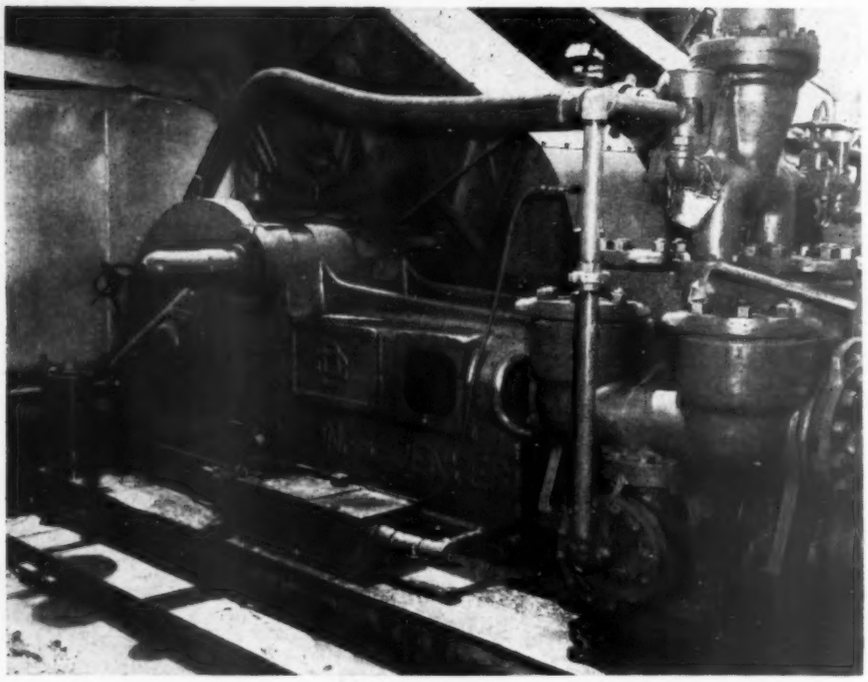
Exploration and Development

Exploration activity in the basin is on an unprecedented scale. In the month of July 1952, 20 wildcat rigs were operating in Montana, and 8 development wells were drilling. North Dakota had 11 wildcats, and 15 development wells, and South Dakota had 3 wildcats and none for development. So in the basin on the American side there was a total of 34 wildcats, and 23 development wells under way.

Seismic work is also being conducted on a large scale, and in July 1952, 103 seismic crews were engaged in the basin as a whole. The portion receiving the most attention is East Montana, stressed by the fact that 60 per cent of the total

FIG. 2. Oil analysis.

Formation	Charles	Charles	Charles	Mission Canyon	Devonian	Middle Devonian			Ordovician
Well	Richey N.P. 1	Murphy East Poplar Unit 1	Husky N.P. 1	Amerada Dilland 1	Pine Unit 1	Amerada Iverson 1			Texas N.P.G. 1
Interval	7183— 7270 ft	5630 — 5692 ft	6817— 6829 ft	8420— 8529 ft	8910— 8970 ft	10,490— 10,530 ft	11,630— 11,660 ft	11,749— 11,797 ft	8745— 9079 ft
Properties									
Gravity A.P.I.....	37.0 deg	33.6 deg	27.3 deg	41.4 deg	33.9 deg	40.7 deg	51.2 deg	43.1 deg	38.5 deg
Pour point.....	+35 F	+5 F	+17 F	—60 F	—20 F	+80 F	—5 F	+40 F	—10 F
Sulfur.....	0.65%	0.44%	1.21%	0.3%	0.43%	0.14%	0.08%	0.32%	0.30%
Gasoline.....	34.5%	17.5%	30.0%	43.5%	29.0%	27.9%	58.3%	35.8%	27.8%
Gas—oil.....	35.1%	21.2%	30.0%	37.6%	35.2%	33.3%	28.0%	19.3%	28.5%
Heavy oil residium	29.0%	60.0%	40.0%	17.7%	35.8%	37.2%	12.4%	43.0%	43.7%



Sturdy slush pumps are required in drilling a well in the Williston Basin on account of the depth.

seismic operations was confined to this particular area.

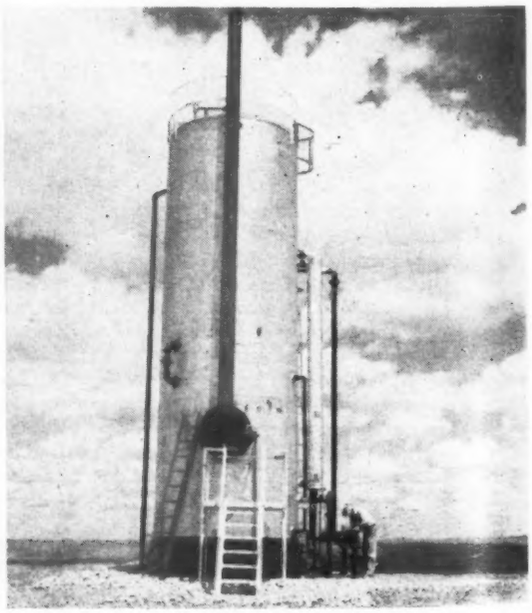
Climate plays an important role in operational activities and the annual temperature range is from 40 deg below zero to 100 F. In some winters the temperature has not risen above the 20 below mark for a month. The greatest hazard is the so called "ground blizzard," consisting usually of 1 to 5 days of continuous snow fall followed by high winds. To reach a rig location it becomes necessary to bulldoze a way in, and then to repeat the task on the return journey because the wind blows the snow and covers the path quickly.

In the early spring when the thaw begins it may be necessary to cease all field operations because of muddy and impassable roads. The operational difficulties are many and as can well be imagined costs are higher compared with those in areas of more temperate climate.

Reservoir Characteristics

In order to avoid technical complexities the discussion on the Williston Basin will be confined to the area on the American side. The basin is so large,

Shell discovery well of the Pine field produces 230 bbl oil per day and has a 33 per cent water cut. Perforations are at 8910 to 8970 ft.



A water treater is used in the Glendive field for processing the produced crude.

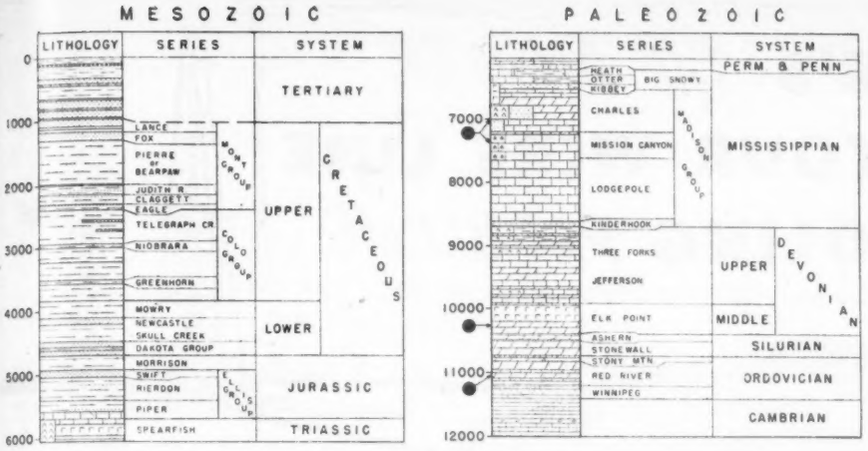


FIG. 3. WILLISTON BASIN — general stratigraphic section.

and comparatively so little has been presently developed that it is not possible to describe pay formations or reservoirs with accurate factual details. A state of flux exists and varying and contradictory results are obtained over wide areas. Again it is a question of time, progressive accomplishment, and the assembling of pertinent well or field data before evaluations and stipulations can be made with reliability.

Commercial production has been obtained so far in the Nesson anticline in North Dakota, and the Cedar Creek anticline in Montana, and also from smaller structural features, such as those of Richey and Poplar in Montana.

Producing depths vary between 5000 and 13,000 ft and the gravity range of the oil is 27.3 to 51.2 deg API (See Fig. 2). Pour points vary considerably, minus 60 F to 80 F above. To date the sulfur content of the produced oil is low, the maximum being 1.21 per cent. Thus far, GOR's in the basin have a tendency to be low, and can be expected to be 500 cu ft per barrel or less.

All the current production is from limestone and the formations are Mississippian, Devonian, and Silurian-Ordovician (See Figs. 3 and 4), which yield a sweet type non-saturated crude. Gas production has not predominated by any means, at least up to the present time. Some of the oil produces a gasoline of low octane rating, around 20, and grades up to 60 octane are obtained. In the Mississippian section the oil accumulation occurs partly in fractures, whereas in the Devonian and Silurian-Ordovician it is in a vuggy and intergranular zone.

The greatest problems confronting an operator in the basin today is that of determining the appropriate completion technique. On account of insufficient correlation data and the inherent variable and peculiar characteristics of the limestone itself the completion requires careful considerations, particularly from an economical standpoint.

Completions and Production

The Williston Basin limestone as a general rule needs acidizing for obtaining production and because of multiplicity of zones it is problematical where the casing should be set. In addition to

FIG. 4.

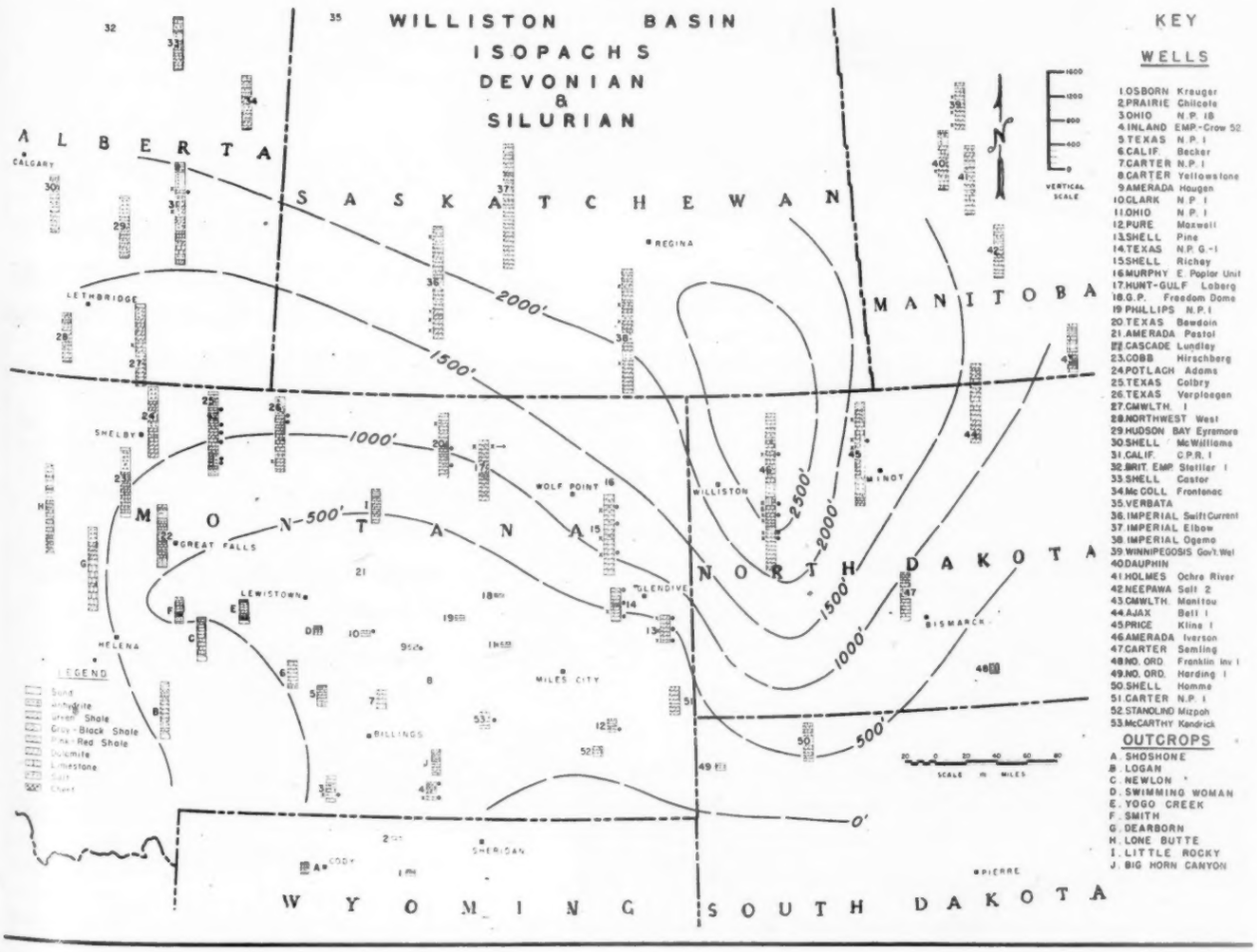


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FIG. 5. Crude oil status for Montana, April 1952. (Bbl oil).

	Big wall	Bowes	Cat Creek	Cut Bank	Elk Basin	Kevin-Sunburst	Pondera	Reagan	All other fields	Total
In storage April 1:										
By producers	3,925	5,071	5,318	114,073	11,454	18,322	7,428	2,291	22,281	190,163
By transporters	1,533	1,179	11,138	282,673	.....	13,776	25,893	.....	10,948	347,140
By refiners	15,411	.....	9,789	77,159	.....	86,552	12,057	.....	2,674	203,642
Total storage	20,869	6,250	26,245	473,905	11,454	118,650	45,378	2,291	35,903	740,945
Produced during month	29,612	57,574	23,264	220,750	125,139	120,071	58,990	17,862	46,051*	699,313
Total	50,481	63,824	49,509	694,655	136,593	238,721	104,368	20,153	81,954	1,440,258
Refined in Montana	28,155	.....	9,541	89,860	77,678	37,844	24,419	17,930	18,434	303,861
Used for fuel or lost	1,244	(1,287)	176	3,948	.....	2,377	(720)	.....	928	6,666
Shipped to other states	.....	57,821	.....	.....	48,925	.....	.....	.....	29,297	136,043
Total	29,399	56,534	9,717	93,808	126,603	40,221	23,699	17,930	48,659	446,570
In storage April 30:										
By producers	4,358	4,470	4,778	108,340	9,990	18,270	6,781	2,223	19,186	178,396
By transporters	1,534	2,820	9,346	364,354	.....	15,100	61,384	.....	9,177	463,715
By refiners	15,190	.....	25,668	128,153	.....	165,130	12,504	.....	4,932	351,577
Total storage	21,082	7,290	39,792	600,847	9,990	198,500	80,669	2,223	33,295	993,688

Wyoming Oil Imported

In storage April 1, 1952	April receipts Montana refineries	Refined	In storage April 30, 1952
333,622	764,887	590,175	508,334

() Pipe line gain—deduct.

* Bears Den 237; Berthelote None; Border 1,115; Brady 100; Clark's Fork 502; Dry Creek 4575; Flat Coulee 27; Frannie 2061; Gage 888; Glendive[1] 3671; Lake Basin 65; Melstone 12,696; Mosser 1083; Pine Unit Area[2] 1554; Ragged Point 2989; Richey[3] 3116; Soap Creek 3902; Sumatra 2689; Whitlash 4781.

Note—([1], [2] and [3] denotes Montana Williston Basin)

DATA—Montana Oil Conservation Board.

this the formations have a tendency to produce water and this is particularly so in the Mississippian limestone.

Assuming the casing depth has been determined, which is a major decision, and that the well will produce, the next problem will certainly be a matter of assessing the maximum efficient rate of production. How to open up the zone and yet restrict the water influx? A satisfactory solution has not been evolved at the moment.

As an example of water intrusion the following may be given as a typical case. A well in the Richey field that produces from a fractured zone may have an open flow of approximately 2000 bbl gross and 1600 bbl net, that is 400 bbl water, or 25 per cent. By reducing the bean size, the oil can be produced with a 2 per cent water cut, but, of course, crude production is thereby impaired.

The present completion practice is to set the casing on bottom, perforate, and acidize. In the Pine field, a one well field to date, the discovery well had to be placed on the pump immediately following completion. (Only one well in the basin has been completed as an open hole producer, this was the Texas discovery well at Glendive).

As the basin is undergoing an exploratory phase, production is relatively small. In Montana for the month of April, 1952, the Glendive field was producing approximately 4000 bbl oil, the Pine field (Shell) some 1550 bbl oil, and Shell's Richey field had over 3100 bbl oil. (See Fig. 5 Conservation Board of Montana).

Daily production figures for some of the wells in the Montana part of the basin are as follows. The Pine field produces on the pump 230 bbl oil daily and a 33 per cent water cut though perfora-

Drilling a well in the Williston Basin presents the operator with a serious completion problem. It is difficult to decide on a precise completion technique as the limestone has such varying tendencies. Perforating casing and acidizing is general practice.

Ditch cuttings are taken at regular intervals in the limestone. A microscopic analysis is made to assist in determining zones of porosity. H. Bardwell attends to the samples at Shell's Pine Unit No. 14-29.

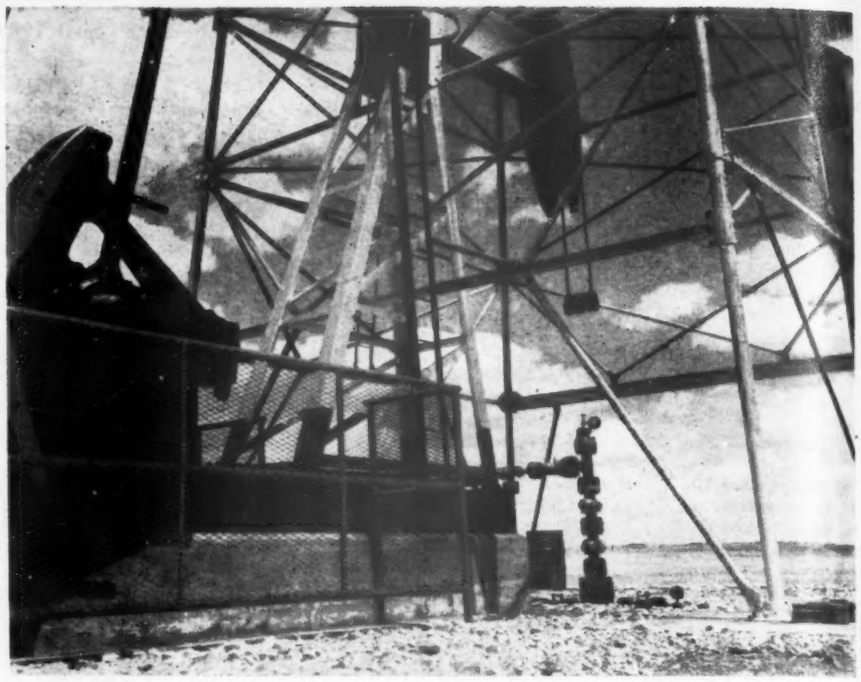
tions at 8910 to 8970 ft. In the Glendive field Government Well No. 34-26 yields 200 bbl oil daily and a 15 per cent water cut on a 8/64-in. choke with a tubing head pressure of 1100 psi. The open flow potential of this well was 4000 bbl oil daily and a 22 per cent water cut. The Richey NP-1 produces 160 bbl oil daily and a 13 per cent water cut on a 7/64-in. choke with a tubing head pressure of 800 psi. Open flow potential of the NP-1 well was 1650 bbl oil daily and a 25 per cent water cut.

Because drilling activity is widely dispersed over a vast area in the Williston, one would anticipate considerable variations in the method of operations. This is actually the case, and because of that, generalities would be completely meaningless, so a specific well is chosen in an attempt to illustrate a particular phase.

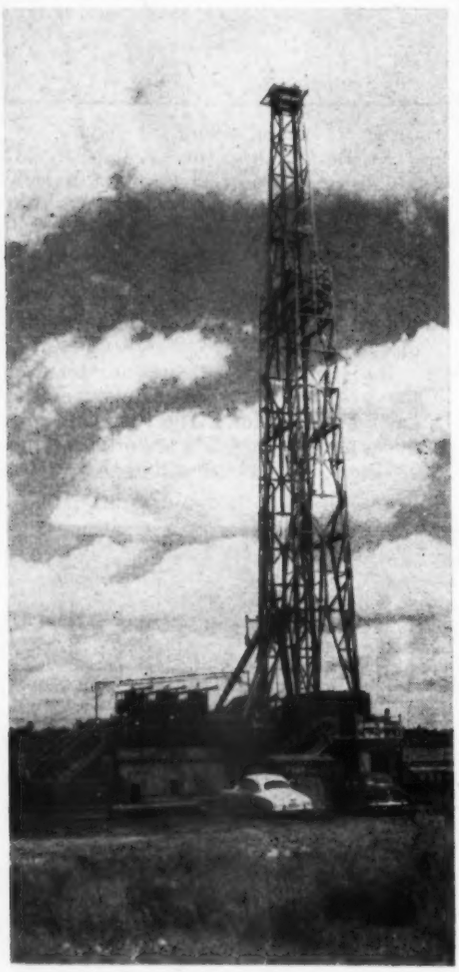
Drilling

The well is a wildcat 100 miles north of Glendive on the Poplar anticline (Montana), Ajax Oil Company, McGowan No. 1, and was drilled by Clark Drilling Company of Billings, Montana.

The location was spotted in January, 1952, and due to the intense winter, moving-in and rigging up took two weeks.



Flowing well near Glendive, Montana, with pumping installations standing ready.



Pine field, Montana. Drilling Pine Unit No. 14-29 at 8100 ft in a limestone formation with an Emsco jack knife derrick. Projected depth is 9000 ft. Pioneer Drilling Company is the contractor for Shell.

To emphasize the weather condition a total of 85 hours was consumed for bulldozing the location site and mud pits.

Total depth of the well is approximately 6300 ft including about 100 ft penetration into the Madison lime, (Mississippian). A short string of surface casing was set and drilling to 3100 ft was quite normal. One surface bit (13¾ in.) and three 9-in. bits were used down to this depth—a 9-in. bit averaged 900 ft. The time taken to drill to 3100 ft was 12 days, or an average of 290 ft per day.

To drill from 3100 ft to 6300 ft required an additional 50 days, but this included time for diamond coring, 10 conventional cores, and 4 drill stem tests. Twenty-five bits were required in drilling from 3100 to 6300 ft; for drilling, a roller type bit was considered the most satisfactory. The actual average rate of penetration in this well was 100 ft per day.

From 400 ft six drill collars were carried, and down to 5000 ft the rotary table speed was 100-120 rpm. From 5000 ft the speed was reduced to 75 rpm and the bit weight increased to 26,000 lb.

At 4300 ft, because the possibility of encountering anhydrite formations, the mud was converted to a gyp base. A 5½-in. oil string was set at 6270 ft and was perforated. A series of acidizations and tests were then required to evaluate the producing ability of the well.

Costs

The cost for drilling to 6300 ft was $60,000, of which $1500 was charged for moving-in, $3000 for rigging-up, and the mud bill of about $3000. (Mud costs for this depth may be as high as $10,000). The 5½-in. casing was an additional $14,000 which makes a total of $74,000, that is to the setting of the 5½-in. casing. (From this point on, costs may vary considerably and are mainly dependent upon the acidization requirements.) A further minimum expenditure of $20,000 was necessary to obtain production. This was made up as follows, $5000 for perforating, acidizing, testing, and squeeze cementing; $5000 for tubing; and $10,000 for surface production equipment. The total cost for the 6300 ft well was $94,000 and a further $10,000 will be spent if pumping equipment is necessary.

It may be argued that this, say $100,000, is the outlay for an initial producer and succeeding wells would not require the tank battery installations as in the first well. This point is conceded, but with a proviso that an offset well may run a $10,000 mud bill or, the later stages of completion, such as acidizing, may cost $10,000 or more. That is the crux of the whole matter in the Williston today, namely how much is a well going to cost before production is obtained, and, when it produces at what rates will it flow, or even pump.

When the conversion occurs from the exploratory stage to that of development then a market outlet will have to be sought for the Williston oil. The basin is situated between two potential areas; one to the east, which would include Chicago and Minneapolis, and one to the west, including Spokane and Seattle.

Regulatory restrictions are not imposed on production rates for the basin at the present time. An operator is, however, confronted with curtailment because of the lack of available outlets.

The enormous Williston Basin in parts has yielded commercial production, even though the operations are in the early stages, many operators have hopes and believe that the basin has oil and gas reserves of major proportions. The operations today are being actively conducted toward fulfilling those hopes and beliefs. ★ ★ ★

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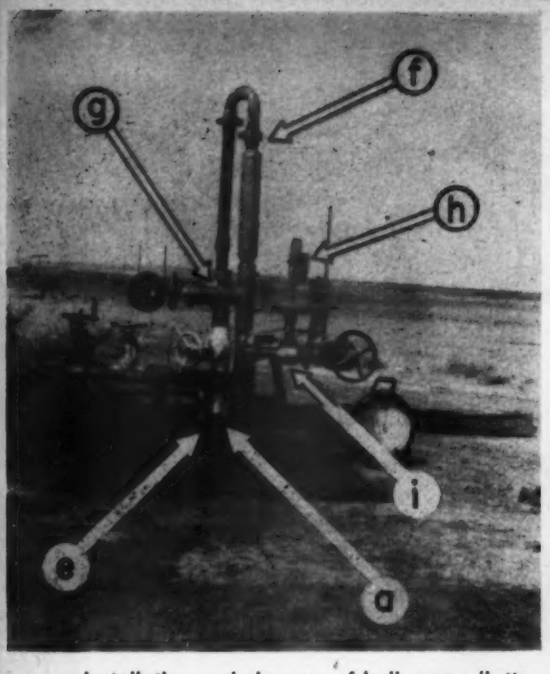
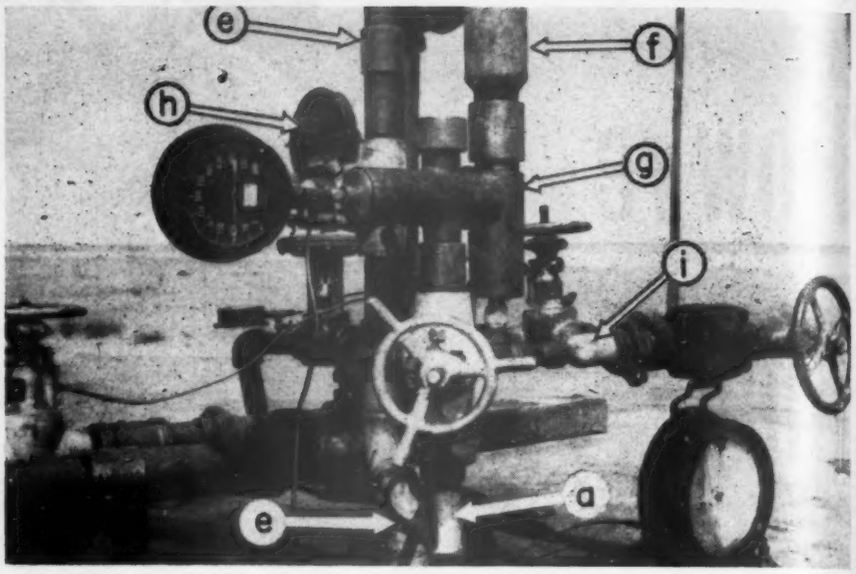




Installation and close-up of ball pump. (Letter designations same as FIG. 1.)

NEW GAS LIFT SYSTEM

Another mark of producing progress is use of the ball pump for more efficient oil recovery.

R. P. VINCENT* and L. B. WILDER*

For some time the oil industry has been seeking an answer to its problem of pumping deep wells, especially those with low fluid levels. A number of developments have come forth, all of them having features in their favor and yet not always universally applicable.

The method described in this paper has several advantages unique to its design, but likewise does not offer a solution to every pumping problem.

In substance, this gas lift system, referred to as a "ball pump," is a gas lift system that eliminates any gas slippage by placing a solid interface between the gas and the oil being lifted. This solid interface is forced down one string of tubing and returns up another string of tubing bringing with it the load of liquid swept from the bottom ends of the two strings of tubing. Variable diameter solid interfaces may be used, so that a small diameter tubing may be used for the downward path of the solid interface, and a larger diameter tubing used for the upward path. The double string of tubing is the only real limitation and disadvantage of the ball pump when compared to other gas lift systems.

The ball pumps now operating use as the solid interface the readily available synthetic rubber balls used for scraping paraffin from surface flow lines —hence, the name "ball pump." Two strings of tubing equal in diameter are used. This cyclic system of operation offers some very attractive features which are, no doubt, obvious to operating people, but are believed worth listing.

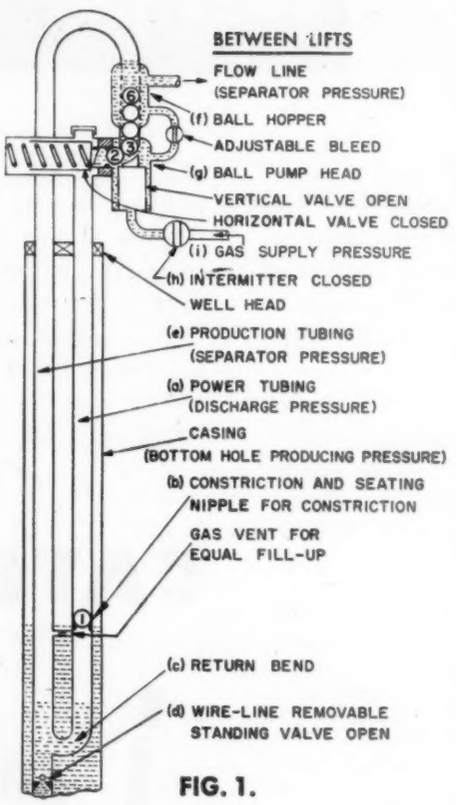


FIG. 1.

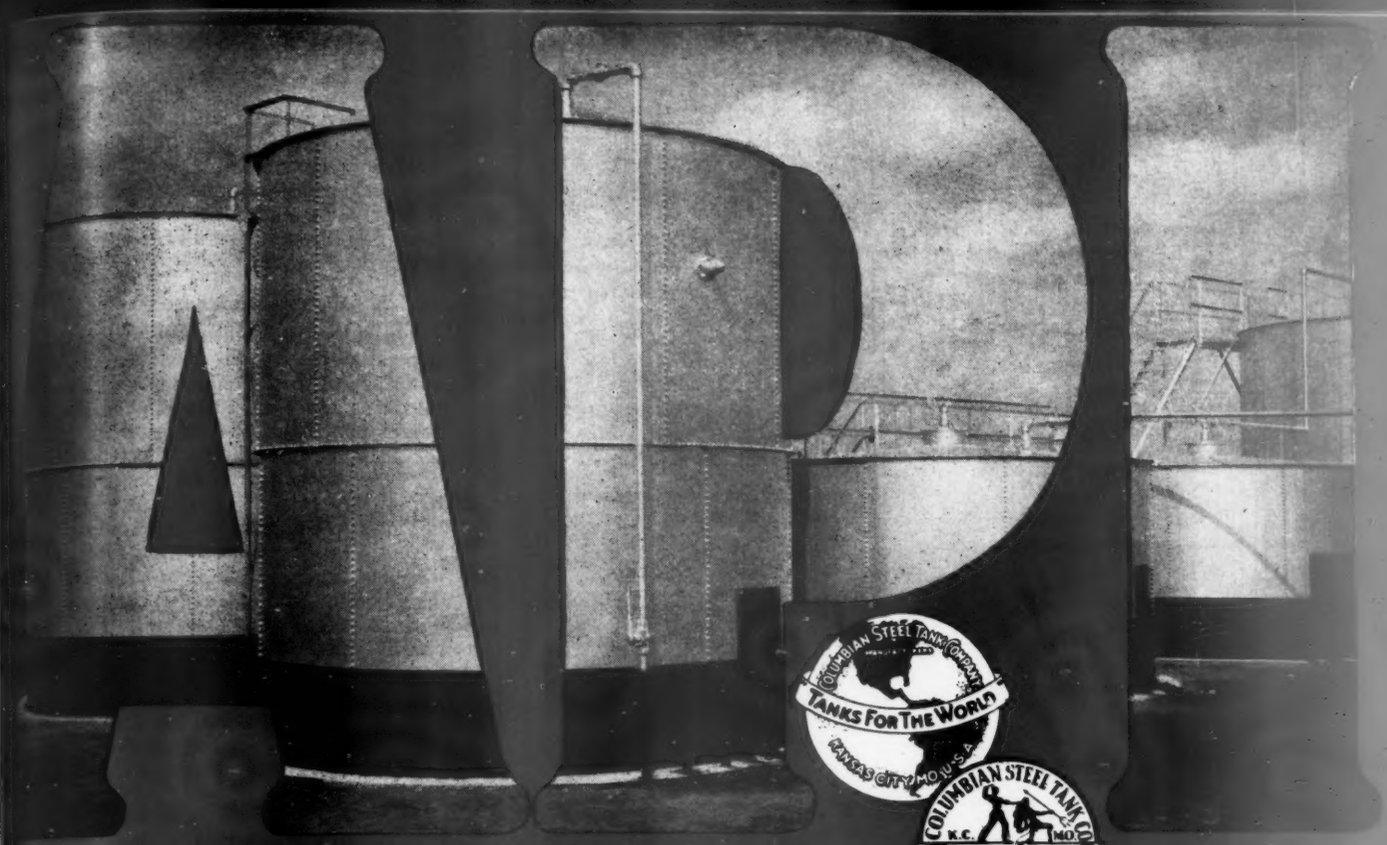
When operated as an intermittent gas lift system, balls are always at the bottom of the well ready to pick up a load of oil and bring it to the surface. There is no waiting time, for example, for a plunger to fall. Foamy crude or free gas production will not penalize its "volumetric efficiency"—it is always 100 per cent.

The cycling system provides a positive means for introducing chemical corrosion inhibitors, the passing of balls through the production string keeps paraffin accumulation to a minimum, and suspended sand can be handled without unusual difficulty.

Pressure differentials across the tubing (inside to outside) need never be over 300-400 psi. There is not a full column of liquid subjected to pulsating loads exerting 3000 to 4000 psi pressure differential (for a 10,000-ft well) across tubing collars, valves, etc.

Minimum back pressure, varying from separator pressure as a maximum down

*Stanolind Oil and Gas Company.



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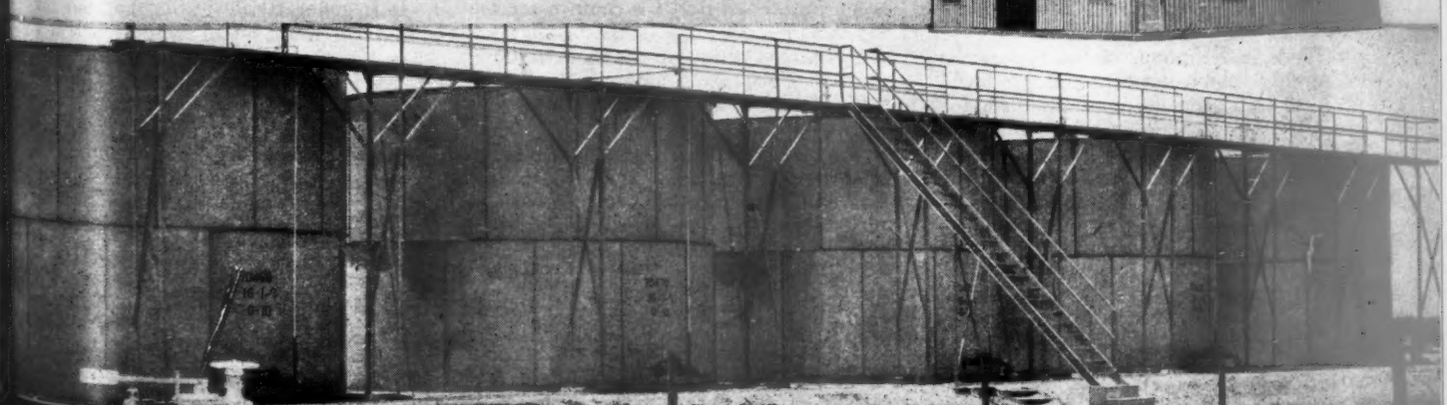


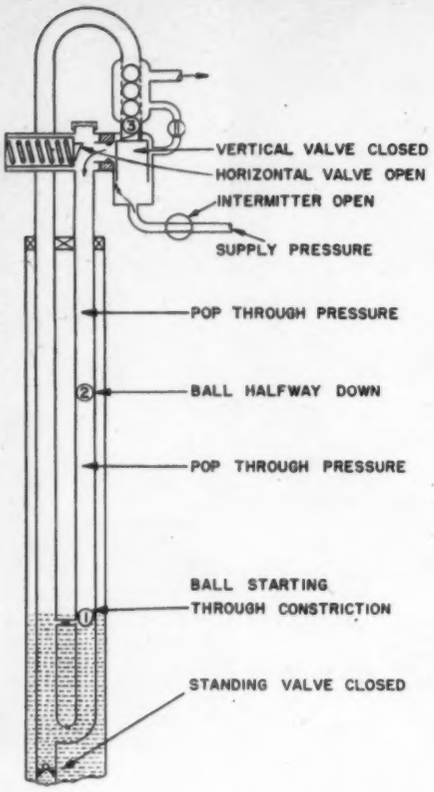


FIG. 2.
Beginning of lift cycle.

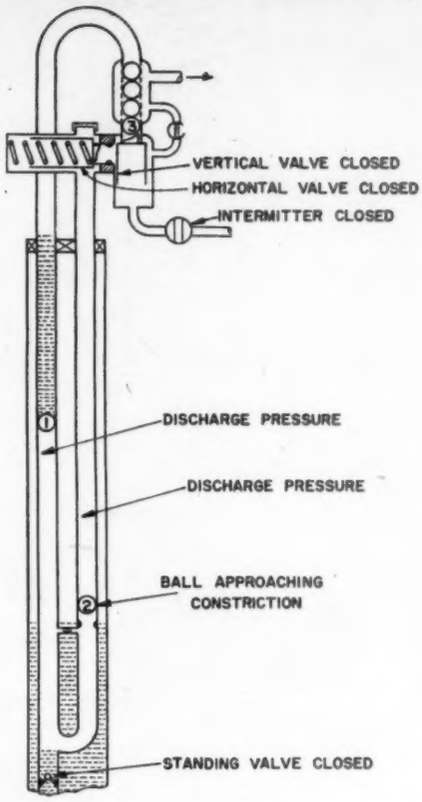


FIG. 3.
Lift condition.

to as low as atmospheric pressure, can be maintained against the formation, and the system is adaptable to the use of accumulation chambers. The lifting cycles can be timed to any desirable frequency by a clock controlled motor valve.

Mechanical Features

The elements of a typical ball pump installation are listed below. These can be visualized by referring to Fig. 1.

(a) A string of tubing through which gas is injected.

(b) A constriction at the bottom of the gas injection string on which a rubber ball sets and through which it passes when the gas pressure is increased sufficiently. This constriction is removable by pumping a ball through the system in reverse and thus carrying the constriction to the surface.

(c) A return bend at the bottom through which the ball, followed by a charge of gas, passes to enter the producing string of tubing.

(d) A removable standing valve, beneath the return bend, which keeps back pressure off the formation.

(e) A production string of tubing through which the oil is lifted to the surface.

(f) A ball hopper at the top of the assembly which collects the produced rubber balls and accumulates them for re-injection into the gas injection string.

(g) A pressure-operated, specially designed ball pump head which injects one ball into the power tubing ahead of each charge of injected gas.

(h) Standard pressure regulators, time-controlling devices, etc., which complete the surface control section.

(i) A supply of gas pressures of 100 to 400 psi is generally most desirable.

Description of Operating Cycle

Fig. 1 shows the conditions between lifts. Ball 6 has delivered the last slug of oil against separator pressure. The gas in the production tubing is expanded nearly to separator pressure except for the flow line friction.

The intermitter is closed. The vertical valve has dropped open by gravity as the pressure around it has been equalized by the bleed connection. The horizontal valve is closed, and pressure sufficient to discharge the next load of oil is held between it and Ball 1, which is restrained by the constriction.

Fig. 2 shows the beginning of a cycle. The intermitter has opened. The gas flow has carried the vertical valve upward to its seat. The radial clearance around the valve plunger permits free flow of gas to carry Ball 2 against and to open the horizontal valve, permitting Ball 2 to travel down the power tubing. The horizontal valve is held open temporarily by the gas flow. The gas between Ball 2 and Ball 1 is compressed to pop-through pressure so that Ball 1 is being forced through the constriction when Ball 2 is about half-way down.

Fig. 3 shows the actual lifting condition. The intermitter has closed. The vertical valve is temporarily held closed until the pressure under it bleeds to the separator. The horizontal valve is closed by its spring, as the gas flow from the intermitter stops. Ball 2 is about to stop on the constriction, retaining above it discharge pressure, which is simply the hydrostatic head of the oil slug plus final flow friction and separator pressure, regardless of depth. The gas between Ball 2 and Ball 1 is expanding from pop-through pressure to discharge pressure.

Gas Requirements

The injected gas-oil ratio for this system is subject to absolute control and will operate very satisfactorily with gas-oil ratios as low as 200 to 250 cu ft per barrel per thousand feet of lift; thus, for a 10,000-ft well, the injected GOR should not necessarily be over 2500 cu ft per barrel.

The gas consumption is simply that required to fill the production tubing to displace the head of oil of each cycle. This volume is of course a function of both the tubing volume and the discharge pressure behind the ball as it reaches the surface. For intermittent lifting cycles, this discharge pressure may vary from 30 to 200 psi above separator pressure, depending upon how the individual operator chooses to produce his well.

In general, the gas consumption for a given daily production is the same for a large number of smaller heads as for a small number of larger heads, because the pressure required varies as the height of the head of oil carried in each cycle and the same tubing volume is involved in each case. Similarly, the efficiency is not much altered by appreciable change of the pop-through pressure required to force the ball through the constriction. This may be set at anything between the discharge pressure and twice the discharge pressure. The pop-through pressure should be high enough so that the volume of gas involved (confined between Balls 1 and 2 on Fig. 2) can expand to the volume of the production string of tubing and still have adequate discharge pressure to complete the cycle. An approximate scale of optimum pop-through pressure versus depth is as follows:

Typical Pop-Through Pressures

Depth, ft..	4000 ft		8000 ft		12,000 ft	
BOPD....	25	75	25	75	25	75
Separator pressure psig						
0.....	55	145	70	195	85	240
15.....	80	170	95	220	110	265
50.....	140	230	155	280	170	325

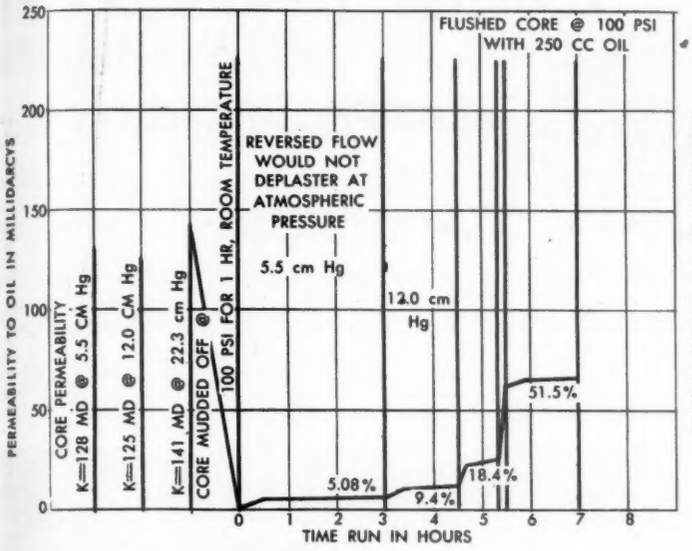
The table reflects the necessity for longer cycles as depth increases and greater loads per cycle as daily production increases, both requiring greater lift pressures.

It is generally desirable that the gas supply pressure be 50 to 100 lb greater than the pop-through pressure in order to provide a rapid supply of gas through the intermitter and surface fittings.

One installation in West Texas has operated satisfactorily over a period of several months. Another installation has recently been made in West Edmond field, Oklahoma, and is operating very satisfactorily. ★ ★ ★

Deplastering oil:
50% white mineral oil
50% Xylene
Visc. @ 80 F = 4 cps
Aniline point = 138 F

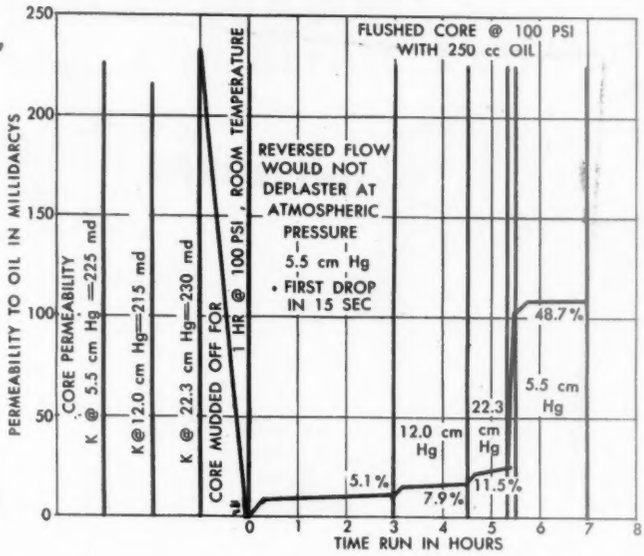
Emulsion characteristics:
Weight: 74 lb/cu ft or 9.9 lb/gal
Viscosity: 65 sec @ 100 F
Fluid loss: 0.4 cc in 30 min @ 100 psi through filter paper, room temp
Emulsion fluid loss: 1.1 cc from core in 60 min at 100 psi, room temp
Gravity crude oil: 30 API
30% crude oil
15 lb emulsifier/bbl emulsion
80 lb/cu ft P-95 clay water mud base


PERMEABILITY TO OIL IN MILLIDARCYS
CORE PERMEABILITY
K=128 MD @ 5.5 CM Hg
K=125 MD @ 12.0 CM Hg
K=141 MD @ 22.3 cm Hg
CORE MUDDED OFF @ 100 PSI FOR 1 HR, ROOM TEMPERATURE
REVERSED FLOW WOULD NOT DEPLASTER AT ATMOSPHERIC PRESSURE
5.5 cm Hg
12.0 cm Hg
FLUSHED CORE @ 100 PSI WITH 250 CC OIL
5.08%
9.4%
18.4%
51.5%
TIME RUN IN HOURS

Per cent return permeability —
Type "A" oil in water emulsion mud.

Deplastering oil:
50% White mineral oil
50% Xylene
Visc @ 80 F = 4 cps
Aniline point = 138 F

Emulsion characteristics:
Weight: 68 lb/cu ft or 9.1 lb/gal
Viscosity: 56 sec @ 100 F
Fluid loss: 2 cc in 60 min @ 100 psi, room temp, from core
Fluid loss: 0.4 cc in 30 min @ 100 psi through filter paper, room temp
35-40% crude oil


PERMEABILITY TO OIL IN MILLIDARCYS
CORE PERMEABILITY
K @ 5.5 cm Hg =225 md
K@12.0 cm Hg=215 md
K @ 22.3 cm Hg=230 md
CORE MUDDED OFF FOR 1 HR @ 100 PSI, ROOM TEMPERATURE
REVERSED FLOW WOULD NOT DEPLASTER AT ATMOSPHERIC PRESSURE
5.5 cm Hg
• FIRST DROP IN 15 SEC
FLUSHED CORE @ 100 PSI WITH 250 cc OIL
12.0 cm Hg
22.3 cm Hg
5.5 cm Hg
5.1%
7.9%
11.5%
48.7%
TIME RUN IN HOURS

Per cent return permeability —
Type "E" oil in water emulsion mud.

EMULSION DRILLING FLUIDS

DOYNE L. WILSON

EMULSION drilling fluids are assuming an increasingly important position in drilling fluid technology. Because of their flexibility they are ideally adapted to function as intermediates between oil base drilling fluids and claywater drilling fluids.

Emulsion stability under severe operating conditions is essential if the drilling fluid is to function properly. If the emulsifying agent is adversely affected by anhydrite, cement, sodium chloride, ions of calcium and magnesium, and other contaminants encountered during the drilling operation, the emulsion will become unstable with separation of its phases, and loss of all desirable properties as an emulsion drilling fluid. By judicious choice of emulsifying agent, emulsions may be obtained are stable to either, or all, of these influences.

At this stage it is desirable to review briefly several emulsion fundamentals.

An emulsion is usually defined as a suspension of fine droplets of one liquid within another liquid with which it is immiscible. The principal components of an emulsion are termed phases; the suspended liquid is the dispersed phase, and the media of suspension the outer or continuous phase(s).

To assure physical emulsion stability an effective method of preventing contact between the dispersed particles must be used. One method of accomplishing this is to form a protective, resistant, non-adhesive film around the dispersed droplets, which will protect them from coalescence due to contact. Experience has shown that the film-forming protective agents are usually materials soluble in the external liquid phase and relatively insoluble in the liquid constituting dispersed droplets.

This paper, which was presented at the Third World Petroleum Congress, has been thoroughly abstracted and many of the charts, tables, pictures, and data have not been included due to available publishing space. A limited number of complete reprints of this article, as presented at The Hague, may be obtained gratis by writing Oil Base, Inc., Compton, California.

The type of emulsion formed will depend primarily upon the emulsifier. When water is the continuous phase the emulsion is known as the oil-in-water type. Conversely, when water is the dispersed phase the emulsion is known as the water-in-oil type.

Emulsion drilling fluids of both types are being used, the selection of type is usually dependent upon the requirements of the operator. When oil is the continuous phase the emulsion drilling fluid has properties closely allied with those of an oil base drilling fluid. If water is the continuous phase the emulsion drilling fluid has properties in common with a clay-water fluid.

Emulsion drilling fluids, generally, have a low water loss, reductions of 90 per cent or more being possible. With the most effective emulsifiers it is possible to obtain, and maintain, zero API fluid loss. This is seldom required, however, as most operators prefer some fluid loss under API conditions as an indication that a better drilling rate can be obtained. Low fluid losses from the emulsion drilling fluids result in holes that are close to gage, drilling speed is

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FRANK C. CARPENTER
Drilling Superintendent

Mr. H. W. Cardwell
Cardwell Mfg. Co.
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Wichita, Kansas

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Sincerely yours,

Frank C. Carpenter

F. C. Carpenter, Drilling Supt.
Universal Drilling Corporation

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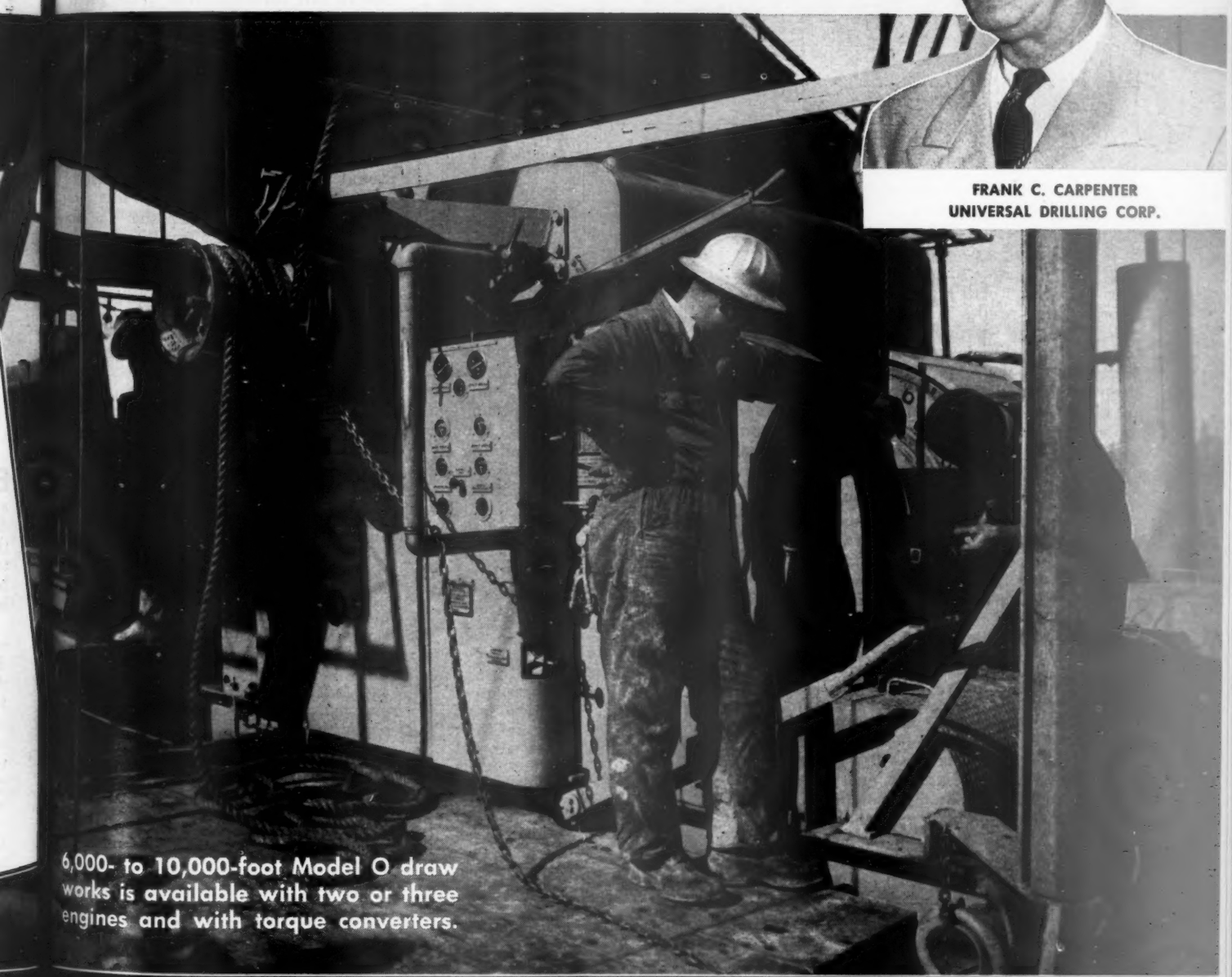

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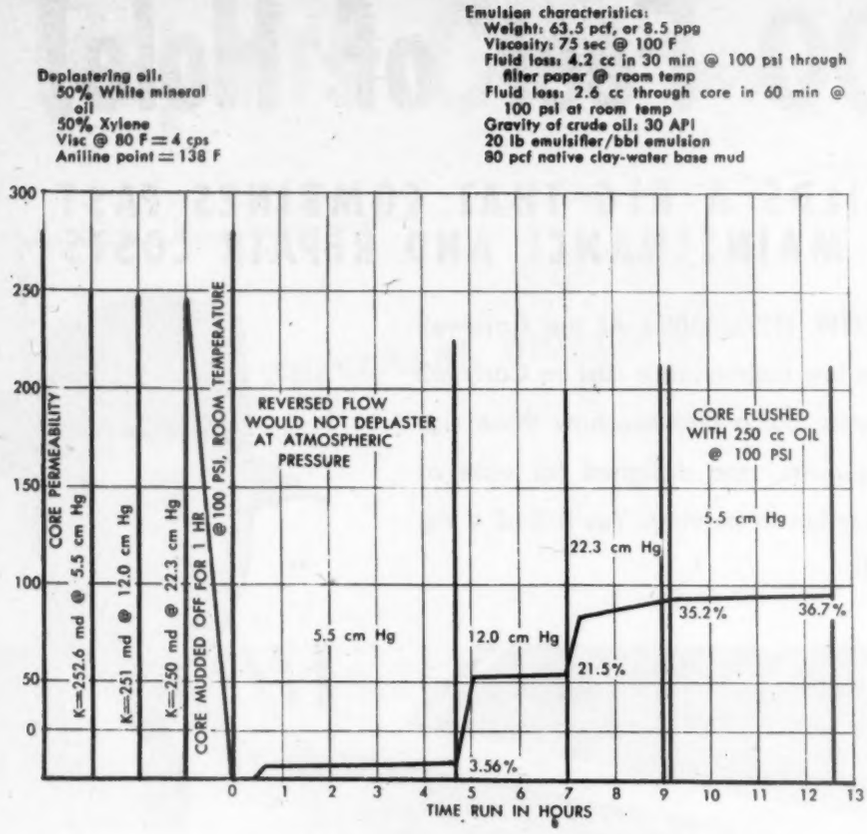
Deplastering oil:
50% White mineral oil
50% Xylene
Visc @ 80 F = 4 cps
Aniline point = 138 F
Emulsion characteristics:
Weight: 63.5 pcf, or 8.5 ppg
Viscosity: 75 sec @ 100 F
Fluid loss: 4.2 cc in 30 min @ 100 psi through filter paper @ room temp
Fluid loss: 2.6 cc through core in 60 min @ 100 psi at room temp
Gravity of crude oil: 30 API
20 lb emulsifier/bbl emulsion
80 pcf native clay-water base mud
CORE PERMEABILITY
K=252.6 md @ 5.5 cm Hg
K=251 md @ 12.0 cm Hg
K=250 md @ 22.3 cm Hg
CORE MUDDED OFF FOR 1 HR @ 100 PSI, ROOM TEMPERATURE
REVERSED FLOW WOULD NOT DEPLASTER AT ATMOSPHERIC PRESSURE
CORE FLUSHED WITH 250 cc OIL @ 100 PSI
5.5 cm Hg
12.0 cm Hg
22.3 cm Hg
5.5 cm Hg
3.56%
21.5%
35.2%
36.7%
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
TIME RUN IN HOURS

Per cent return permeability — Type "C" oil in water emulsion mud.

increased due to a combination of longer bit life and, consequently, less round trips. A reduced drill pipe torque is obtained, which results in less power requirements, and few drill pipe and drill collar failures. Emulsion drilling fluids, particularly of the oil-in-water type, are electrically conductive and accurate logs are obtained with normal electrical survey equipment.

Types of Oil Emulsion Fluids

Type A. Oil-in-Water Emulsion.

This emulsion drilling fluid is prepared from clay-water mud, crude or refined oil, and emulsifier A. The active ingredients in this commercial product include a high molecular weight polymeric member of the polyethylene glycol series having the general formula

$$HOCH_2(CH_2OCH_2)_x\ CH_2OH.$$

and the disodium derivative of a highly complex polymer of many homogeneous units, having a unit weight of about 840 each, containing four methoxyl groups, four or more hydroxyl groups, and perhaps one carbonyl group. The solubility of the disodium derivative is thought due to the phenolic character of one of the hydroxyl groups and to enolization of the carbonyl group.

The active ingredients described above function jointly, when in the correct portions, to stabilize and activate the clay particles in the clay-water mud so that the oil is not only emulsified in the aqueous phase, but is associated with the clay through the activating influence of the long-chain polymers resulting in an emulsion system so tightly integrated that no oil droplets are discernible under the microscope.

Field preparation of Type A emulsion drilling fluid with emulsifier A is very simple. The powder is added to the clay-water mud through the hopper while the oil—any crude or refined oil suitable—is added to the contents of the pit with agitation obtained by a bottom-type mud gun. Emulsification occurs at once, and without the necessity of adding additional chemicals such as caustic soda to activate the emulsifier in situ. A top-type mud gun may be used, if care is exercised to keep the nozzle below the surface of the fluid to minimize foaming due to incorporation of air.

Type A emulsion, when prepared as described, has a pH of approximately 9.5, and is very stable to contaminants such as those encountered in brines, hard water, cement, anhydrite, etc., during drilling operations.

When excessive contamination is anticipated the Type A emulsion drilling fluid may be easily converted to a high pH lime-base emulsion by the addition of the following materials per barrel of emulsion mud: Quebracho, or equivalent substitute, two pounds, caustic soda, one pound, and calcium hydroxide, two pounds. To avoid heavy initial gel build-up the quebracho should be added to the emulsion fluid first, with the caustic soda being added in aqueous solution, followed by the calcium hydroxide. Alternatively, the quebracho and caustic soda may be mixed together in an aqueous solution which is added to the emulsion fluid prior to the lime. This high pH lime-base emulsion fluid is highly resistant to cement contamination, gypsum or anhydrite, and will withstand fairly severe salt contamination if the pH is maintained above 12.8.

Type B. Oil-in-Water Emulsion.

This emulsion drilling fluid is prepared from clay-water mud, crude or refined oil, emulsifier B, quebracho, and sodium acid pyrophosphate. The two latter chemicals function in a conventional manner with respect to dispersion of the clay particles, and also provide a degree of emulsification. The oil, however, is not tightly emulsified and is easily observed under the microscope.

Emulsifier B is poorly soluble in water and functions less as an oil-in-water emulsifier than as a bridging agent. This action is achieved by virtue of its water insolubility and particle size distribution.

Emulsifier B is powdered Douglas fir bark, and consists of a physical combination of three basic constituents of the bark: Cork, lignified fiber, and powder.

Field preparation of Type B emulsion drilling fluid:

1. The clay-water mud should have an API water loss of 10-15 cc.
2. To the clay-water mud in the mixing pit Emulsifier B powder is added through the hopper at a concentration of 4-10 lb per barrel of emulsion, at the same time that crude oil is being added. The per cent of oil to be used will usually be specified by the operator, but will generally be 10 to 30 per cent.
3. To effect further water-loss reduction and viscosity control quebracho and sodium acid pyrophosphate are added in the ratio of 5:1 until the desired result has been obtained.

Type C. Oil-in-Water Emulsion.

This emulsion drilling fluid is prepared from clay-water mud, crude or refined oil, and emulsifier C, which is an aqueous solution of tall oil soap.

Tall oil reacts quickly on contact with alkalies to form soaps of high solubility in cold water, which have a high solvent or coupling action and good dispersing power. Tall oil soaps are characterized by low viscosity of relatively concentrated solutions. Thus, liquid soaps con-

The Author

D. L. Wilson is director of research for Oil Base, Inc., Compton, California. He is a graduate of the University of Arkansas where he obtained his master's degree in chemistry, and has done post-graduate work at the University of Chicago and the University of Southern California. From 1938 to 1947 he was assistant chief chemist for Visco Products Company, Houston, Texas, and joined Oil Base, Inc., in 1947 in his present capacity. He attended the Third World Petroleum Congress where he gave a paper on "Emulsion Drilling Fluids."

taining as much as 45 per cent tall oil soap remain fluid at room temperature.

In common with most other water soluble soaps an aqueous solution of sodium "tallate" is sensitive to electrolytes. For example, sodium chloride will salt out the tall soaps from solution, while calcium and magnesium ions will convert the water soluble soaps to those that are insoluble in water.

These factors have an important bearing on the performance of an oil-in-water emulsion drilling fluid stabilized by Emulsifier C when drilling through salt beds, anhydrite, or when the make-up water is high in ions such as chloride, sulfate, calcium, and magnesium.

Type C emulsion drilling fluid weighted with barium sulfate may disintegrate with separation of the oil phase and settling of the weight material. This may be due to the very slight, but progressive, ionization of the barium sulfate, followed by the formation of water insoluble barium "tallate," thus gradually removing the sodium "tallate" that stabilizes the emulsion.

Field preparation of Type C emulsion drilling fluid:

1. The clay-water mud is placed in a mixing pit and about one-third of the desired oil concentration is added. The addition of a portion of the oil prior to the emulsifier minimizes foaming that would result from the incorporation of air into the mixture of clay-water mud and Emulsifier C by the top mud gun.
2. The mixture of clay-water mud and part of the crude oil is agitated with the mud guns while the emulsifier C is added.
3. The remaining oil is then added and agitation is continued 15-30 min.

Various operators report that Type C emulsion drilling fluids are difficult to maintain when drilling out cement. This is presumably due to the tendency for the calcium ions from the cement to displace the sodium from sodium "tallate" with the formation of water insoluble calcium "tallate."

Type D. Oil-in-Water Emulsion.

This emulsion drilling fluid is prepared from clay-water mud, crude or refined oil, sodium hydroxide, calcium hydroxide, and emulsifier D. The active ingredients in the latter material are the water-insoluble, highly complex humic acids associated with lignite, or brown coal. To function as an emulsifier, emulsifier D must be activated by treatment with sodium hydroxide which induces water solubility.

Type D emulsion is essentially a high pH-lime base drilling fluid. Precautions must be used in the sequence of addition of ingredients to avoid excessive gel and viscosity due to the action of caustic soda and calcium hydroxide on the clay particles.

Field preparation of Type D emulsion drilling fluid:

1. The clay-water mud to be used is adjusted to API viscosity of about 10 sec lower than desired final viscosity.
2. The required quantities of the various ingredients per barrel of finished mud are:

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Here is a pair of hard-working, oil-in-water emulsifiers that definitely speed up the rate of top hole drilling and *will not fluoresce*. When added to normal clay water muds they produce a low-water loss emulsion drilling fluid that slicks up the hole, reduces drill pipe torque, combats mechanical problems, helps to keep a hole "to gauge," overcomes heaving shale and mud contaminating formations, forms a paper-thin, tough, pliable, oily mud cake that lessens the hazards of wash-outs and stuck pipe.

WHITE MAGIC

White Magic is a readily soluble white powdered material packed in 100 pound net sacks. It is added to any regular clay-water mud with crude or refined oil to produce a low water-loss emulsion mud. White Magic does not fluoresce and may be used with No-Glo Oil. Viscosity and gel properties are excellent. White Magic has a flexible weight range, from 60 lbs./cu. ft. (8.02 lbs./gal.) to 140 lbs./cu. ft. (18.8 lbs./gal.) It is electrically conductive, easily controlled, and may be used either with or without caustic soda over all pH ranges of drilling mud.

NO-GLO

No-Glo is a ready-mixed emulsion mud concentrate containing the oil as well as the emulsifier. It provides all of the desirable characteristics for a good oil emulsion mud and will not fluoresce. One drum (390 lbs. net) may be added to every 5bbls. clay-water mud in the system, making a sodium-base emulsion containing about 13% oil. It can easily be converted to a lime-base emulsion, and is the only non-fluorescing, non-cutting emulsion concentrate available today.

NO-GLO OIL

This specially treated, highly refined oil is colorless and non-fluorescing. It may be added to clay water mud equally as effectively as crude or other oils, but has the advantage that it does not impart fluorescence. No-Glo Oil can be spotted for freeing stuck drill pipe in wells where crude oil cannot be used. This oil now makes possible many drilling operations which heretofore have not been possible because of the fluorescing characteristics of crude oil and its derivatives. One drum weighs 357 lbs. net and about 410 lbs. gross. Bulk shipments by rail or tank truck are available domestically.

NO-GLO THREAD LUBRICANT

Packed in 35 pound (net) pails, OB No-Glo Thread Dope is necessary when a non-fluorescing drilling mud is being employed. Most thread dopes in use today will eventually contaminate the mud and defeat the purpose of using a non-fluorescing drilling fluid.

For more information on EMULSION MUDS *write for free copy of the* THIRD WORLD PETROLEUM CONGRESS *paper, "Emulsion Drilling Fluids" by D. L. Wilson.*

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OB Gel
OB Zero
OB Wate
Econo Magic
Voodoo Dust
OB Well Wash
OB Mud Guns
OB No-Glo

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Chemical "V"
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OB Mix Fix
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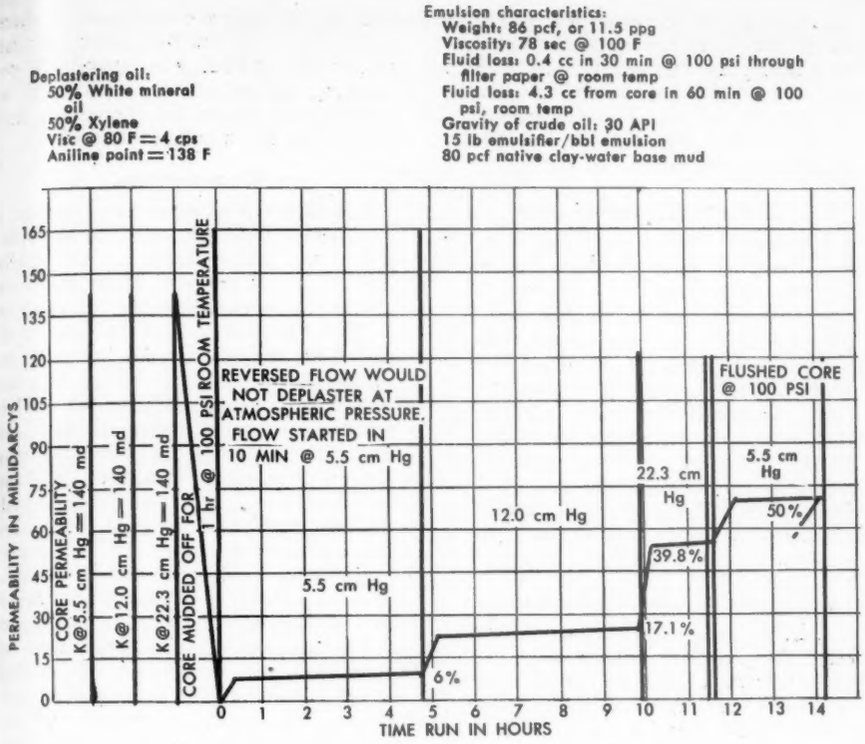

Deplastering oil:
50% White mineral oil
50% Xylene
Visc @ 80 F = 4 cps
Aniline point = 138 F
Emulsion characteristics:
Weight: 86 pcf, or 11.5 ppg
Viscosity: 78 sec @ 100 F
Fluid loss: 0.4 cc in 30 min @ 100 psi through filter paper @ room temp
Fluid loss: 4.3 cc from core in 60 min @ 100 psi, room temp
Gravity of crude oil: 30 API
15 lb emulsifier/bbl emulsion
80 pcf native clay-water base mud
PERMEABILITY IN MILLIDARCYS
CORE PERMEABILITY K@5.5 cm Hg = 140 md
K@12.0 cm Hg = 140 md
K@22.3 cm Hg = 140 md
CORE MUDDED OFF FOR 1 hr @ 100 PSI ROOM TEMPERATURE
REVERSED FLOW WOULD NOT DEPLASTER AT ATMOSPHERIC PRESSURE. FLOW STARTED IN 10 MIN @ 5.5 cm Hg
5.5 cm Hg
6%
12.0 cm Hg
17.1%
22.3 cm Hg
39.8%
FLUSHED CORE @ 100 PSI
5.5 cm Hg
50%
TIME RUN IN HOURS

Per cent return permeability — Type "D" oil in water emulsion mud.

a. Emulsifier D, 6-18 lb.
b. Caustic soda, 2-4 lb.
c. Calcium hydroxide, 1-3 lb.
d. Crude oil, API gravity of 25 or higher, 5-50 per cent by volume.

The chemicals may be added dry, or through the chemical barrel if desired.

The oil is usually added last through the mixing hopper or near the pump suction in the mud pit, with adequate agitation obtained with a mud gun.

Type D emulsion drilling fluid has excellent stability and resistance to contamination. It is reported that when properly treated this type of emulsion fluid will tolerate several per cent of gypsum or anhydrite, relatively large amounts of cement, and, with proper pH control, several per cent of salt. Starch is used to decrease the fluid loss below 1 ml API.

Type E. Oil-in-Water Emulsion.

This emulsion drilling fluid differs from the preceding types in that it contains no clay-water mud, and has a high concentration of sodium chloride. It is prepared from water, crude or refined oil, rock salt (sodium chloride), sodium hydroxide, and emulsifier E. The latter is a modified starch and must be activated by sodium hydroxide before it can function as an emulsifier.

Field preparation of Type E emulsion drilling fluid:

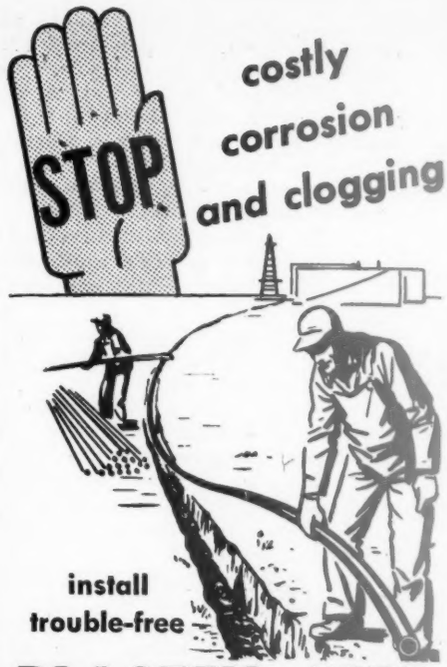
1. Powdered emulsifier E, about 35 lb per barrel, is dispersed in the water.
2. Caustic soda, about 5 lb per barrel of water, is added as a concentrated aqueous solution to the slurry in step 1. The solution becomes very viscous and is subject to frothing due to the incorporation of air.
3. The desired quantity of oil (API gravity 25-45) is added next, with vigorous agitation to cause emulsification.
4. Salt is now added in the desired amount and agitation continued until solution is effected.
5. Weight material, if required, is added and agitation continued until the mud is "smooth" enough for drilling operations.
6. Some of the chemical additives for controlling the properties of this emulsion drilling fluid are: An antifoaming agent, a lignin derivative, aluminum silicate, oxalic acid (in cement cut mud), and boric acid to control liberation of ammonia.

Some objections to Type E emulsion drilling fluid are (1) its relatively high initial cost, (2) difficulty in field mixing due to large number and required mixing sequence of ingredients, (3) difficult maintenance, (4) aqueous fluid loss into producing formations.

Action on Synthetic Cores

It is well known that completion drilling fluids vary widely in the amount and kind of fluid they lose to the formation. In an ideal core, containing non-hydrateable or reactive materials, it should be possible to evaluate the relative blocking tendencies of drilling fluids of the same, or related, type by (1) determining the permeability of the core to a specific oil at varying pressures, (2) mudding off the core with the drilling fluid under fixed conditions of pressure, time, and temperature, (3) reversing the core with its filter cake, and determining the per cent return permeability with the same oil as in (1).

Data were obtained by this method with a number of drilling fluids of the water-base and oil-in-water emulsion types, using a specially designed apparatus fitted with reversible, synthetic,



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alundum cores to which air could be admitted under varying pressures. The cores used were 2¾ in. in diameter by ½ in. thick, nonbevelled, with an air permeability of 150-300 md, and are manufactured by the Norton Company, Worchester, Massachusetts.

The procedure for determining return permeability was as follows:

(1) The permeability of the core to air and to oil (50 per cent white mineral oil, 50 per cent xylene) was determined.

(2) The core was "mudded off" with the drilling fluid for one hour at 100 psi, at room temperature.

(3) The core with its filter cake was reversed, the cylinder filled with the deplastering oil (same as in Step 1).

(4) The time in seconds required for a linear flow of 6 cm of oil (approximately 250 cc) from the cylinder was measured at a pressure of 5.5 cm of mercury above atmospheric pressure until equilibrium was reached. This procedure was repeated at pressures of 12.0 cm and 22.3 cm of mercury. The core was flushed with 250 cc of deplastering oil at 100 psi, then the run at 5.5 cm of mercury was repeated.

(5) Calculations were made using the following equation:

$$K = \frac{lQ}{A}\frac{U}{pt}$$

where

K = permeability in darcys
l = core thickness in centimeters
Q = throughput in cubic centimeters
A = core area (one face) in square centimeters
U = viscosity in centipoises of throughput medium
p = manometer pressure in atmospheres
t = time in seconds required for unit throughput

Effect of Varying Concentration

One of the chief reasons for converting a clay-water mud to an oil-in-water emulsion drilling fluid is to reduce the fluid loss and retain the hydrophilic characteristics of the original water-base mud. Economic considerations and, often, supply problems make it necessary for the operator to know how this may best be accomplished with a given emulsifier under various conditions such as type of clay, dissolved solids in the water, and their effect on the clay and on the emulsifier, effect of oil concentration on fluid loss, viscosity and gel, conversion of the emulsion to a high pH lime-base emulsion, its effect on fluid loss, resistance to contamination by cement, and effect of the latter on fluid loss, viscosity and gel.

Using Type A emulsifier because of its resistance to adverse contamination a series of Type A emulsion drilling fluids was prepared for a study of the various conditions just cited.

Using different clay-water muds for emulsion conversion it was shown that the API fluid loss may be reduced by (1) holding the oil constant and increasing the amount of emulsifier A, (2) A more effective reduction can be obtained by holding the emulsifier constant at a suitable concentration and increasing the amount of oil. The conversion of Type A emulsion did not materially change the characteristic curves.

Cement Contamination

Conducted tests showed that Type A lime base emulsion drilling fluid will tolerate 20 lb of powdered Portland cement per barrel up to concentrations of 30 per cent oil. As the oil concentration increases the amount of cement tolerated diminishes due to increased viscosity, so that at 50 per cent oil concentration the cement drops to 5 lb per barrel. According to Rogers[1] mud contamination by cement seldom exceeds 5 lb per barrel. Thus, Type A lime base emulsion drilling fluid is ideally adapted for cementing operations.

Applications and Uses

Echols[2] and others have indicated that the primary advantages to be gained from a good emulsion drilling fluid are (1) improved drilling speed, (2) increased bit life, and (3) better hole conditions.

In the Wilmington, California, area where complex completions are necessary due to subsidence and sub-surface earth movements less hole trouble has been experienced in the wells drilled and scraped to date with Type A emulsion drilling fluids, and behind the pipe displacements have been much more complete than in the past.

In some areas it is becoming standard procedure, prior to extensive cementing operations or drilling through massive anhydrite, to convert the emulsion drilling fluid in use (unless it contains a soap-type emulsifier which is unstable in the presence of calcium ion) to a high pH lime-base emulsion.

Electric Logging

Electric logging in emulsions is performed in the normal manner since these fluids are electrically conductive.

A company engaged in electric logging gave the following resistivity values for different types of drilling fluids:

1. Oil base 9.55×10^6 ohm-meters
2. Oil-in-water emulsion 20 ohm-meters
3. Clay-water 3 ohm-meters

One electric logging company has expressed the opinion that logs taken in emulsion fluids are more accurate in some cases due to the low fluid losses and consequent reduction in drilling fluid filtrate intrusion. This is particularly significant in depleted sands.

Caliper Logging

Caliper logs are run in the normal manner. In every case investigated caliper logs of holes drilled with emulsion fluids showed a close to gage survey.

From comparisons it may be concluded that a near-gage hole may be expected by use of a properly prepared low water loss emulsion drilling fluid of the oil-in-water type. The advantages are: (1) There is less possibility of formations sloughing in the hole, (2) certain fishing jobs are facilitated as there is no chance of the fish getting too far to one side and being by-passed, (3) cementing operations are successful as there is less chance for channeling, and fill-up can be calculated accurately.

Completions

Emulsions are sometimes used as a completion fluid, although, in the opinion of the author, they are not ideally suited for this purpose. Many zones are known to be permanently damaged by water infiltration, and all emulsion drilling fluids have a filtrate that consists primarily of water, or of an aqueous phase containing the various water-soluble constituents from the emulsion fluid. Even though an emulsion may show a very low API fluid loss, perhaps less than 1 cc, it has been shown in both the laboratory and the field that rather large volumes of water are lost to permeable zones under bottom hole conditions. A careful literature search failed to yield any conclusive data to support the contention of some proponents of emulsions for completion fluid that their use will result in improved well productivity, when compared with results obtained with oil base completion fluids. On the contrary, Echols[2] states "There are no data or observations to indicate that the use of oil-emulsion mud in the Sivells Bend field has contributed toward any improvement in productivity of wells in which it was used."

Conclusions

Emulsion drilling fluids are very flexible in their composition, preparation, and properties. They are particularly well suited for top hole drilling in troublesome areas where formations wash badly or where tight hole conditions exist. It has been demonstrated by Graham[3] that "To obtain a 75 per cent reduction in water loss of the fluid, emulsion would be the most economical, followed by starch and sodium carboxymethyl cellulose."

The use of emulsion drilling fluids is continuing to increase, and operators seem to agree that in troublesome areas their effectiveness has been proved.

Although some engineers recommend emulsions for completion work, it is the opinion of the author that these fluids are not ideal for drilling a pay zone due to the fact that the filtrate from all emulsions is essentially water, or aqueous solutions, which may materially reduce the productivity of the well. If an emulsion fluid is to be used for, however, drilling the pay zone judicious care should be taken to select one that has the least blocking action on the formation, in which the emulsifier is chemically stable in the presence of contaminants, is easy to use, and economical to maintain.

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1. Rogers, W. F., "Composition and Properties of Oil Well Drilling Fluids," Gulf Publish-Co., 1948.
2. Echols, W. H., "Use of Oil Emulsion Mud in the Sivall's Bend Field," AIMME Tech. Pub. No. 2227, Class G, Pet. Tech., July 1947.
3. Graham, Gordon H., "Cost Investigation on Water Loss Reduction," World Oil, February 1, 1949.

★ ★ ★

FIG. 1. Drum crushing.

FIG. 2. Drum crushing. More attention should be paid to winding conditions.

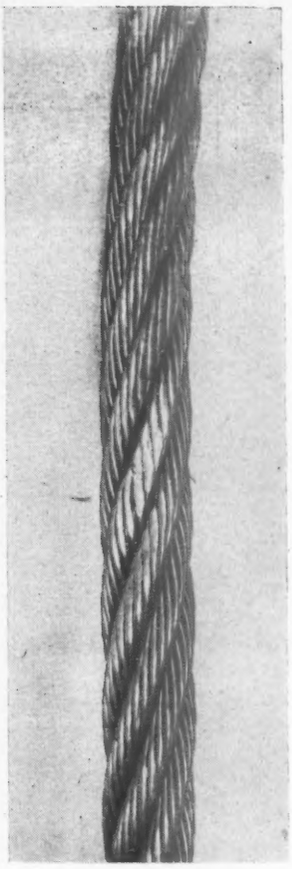

FIG. 3. Cross over wear.

The Role of Wire Rope in Deep Drilling

Increased use of greater weights on drilling ropes makes necessary a study of efficiency and usage of wire rope

C. M. ZERR

THE trend in drilling today leads to production of oil from deeper horizons. Directly related to this, is the fact that greater weights are carried on the drilling lines. Another modern technique in drilling, is that of intentionally carrying heavier weight in the form of as many as 20-25 drill collars in tandum.

Such practices as described above present problems that are not new. They raise questions in the mind of the contractor, the tool pusher, the driller, and those others directly interested in the drilling of a well, as to the increased size and quantity of equipment necessary to handle these new loads. The contractor of today is faced with the use of larger sized ropes, which are naturally needed to handle properly the heavier pipe loads. This, in turn, necessitates acquiring of larger drums and sheaves.

Mechanics

At the present time, the drums are practically at a minimum size for the 1⅛-in. and 1¼-in. ropes that are used. We are now operating near a critical point, with the frequent experience of a crushed rope. This is particularly true when using fiber cored ropes in the deeper holes. The unit pressure of one layer of rope on the other increases with smaller drums. So, it is not only necessary to increase the drum and sheave diameters, to keep the bending stresses to a minimum, but to keep the unit pressures down to reduce the crushing effect. (See Fig. 1.) All these conditions affecting the life of the rope are anticipated in the A.P.I. Recommended Practice on Application, Care and Use of Wire Rope, API RP 9B. Under Recommended Design Features, beginning with paragraph 17, the suggested diameter for drums and sheaves is discussed.

There are other problems dealing with the mechanics of hoisting which are, no doubt, familiar to anybody who has attempted to drill. Their continued recurrence seems to suggest a few comments. The first difficulty encountered is the adverse drum winding when running drill pipe into the hole. Here the blocks are raised at high speed and with no load, which allows the rope to spool

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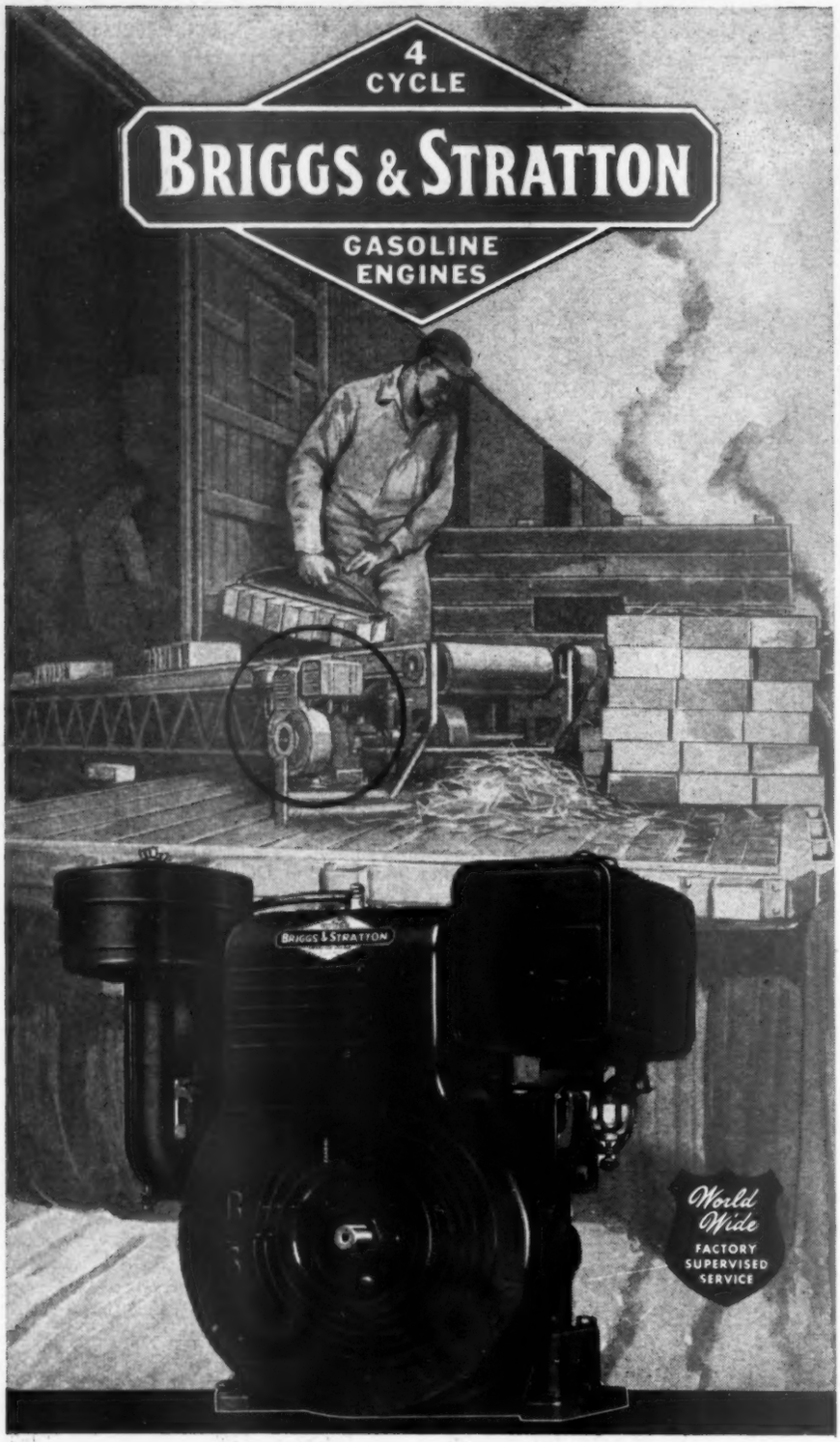

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The Author

C. M. Zerr was graduated from Stevens Institute of Technology, Hoboken, New Jersey, in 1932 with a degree in mechanical engineering. For the next 2 years he spent the time with various construction companies and U. S. Geodetic Survey.

In 1934 he began working in the engineering department of Union Wire Rope, becoming chief engineer in 1946. He is a registered mechanical engineer, State of Missouri, and a member of the American Society of Metals.

rather loosely on the drum. Then, a sudden shock load is applied as the slips are removed, and the string of pipe lowered. This pulls the rope down between the wraps and causes a scrubbing and momentary locking of strands, and results in a severely abraded rope. (See Fig. 2.)

Snubbers, or wire line guides, mounted on the fast line are aids to smoother winding by dampening the vibration that is set up in the line, particularly from the crossover point and the riser point at the flange. (See Figs. 3 and 4.)

The proper location and set up of the drawworks is very important to good rope winding and life. Care must be exercised to be certain that the drum is: (1) centered with the fast sheave, (2) level, and (3) setting square. Otherwise, there will be a tendency for the rope to skip around, particularly at the crossover points on the second and the fourth layers and at the flanges. Constant hoisting with the line in one position results in wire fatigue breaks of the line that is operating on the sheaves. In districts where the drilling is hard, this fatigue shows up more rapidly. Other areas will find this a minimum effect. It is a condition that is present at all times and should be considered when analyzing the problem of today's greater loads. (See Fig. 5.)

One other very vital point, having to do with the mechanics of hoisting, is the method of tying down the dead end. It is an all too common practice to wrap the dead end around a steel or wooden sill. (See Fig. 6.) Not alone does this practice dog-leg the line, but when moving, it is not unusual to put a curl in the line. A condition that results from this practice is more than that reaching the eye in the form of a curly or dog-legged rope; it is the loss of strength due to bending the line sharply.

A considerable amount of work has been done on a study of the efficiency of wire rope bent and statically stressed to destruction over sheaves of various diameters. Several empirical formulae have been derived to calculate the bending stress, but none have proved of much

practical value. Graph 1 (Fig. 9) is presented as a graphic illustration of the loss of strength when a rope is operating over sheaves. The curve is based on many laboratory tests and can be considered accurate within the limits of field practice.

What does this curve mean? A wire rope bent over a sheave is not 100 per cent efficient. The smaller the sheave the greater loss of strength. In cases where the rope is wrapped around sharp corners, 25-30 per cent loss of strength can be expected. When it becomes necessary to load the rotary line to low ratios of wire rope strength/load (design factor), field practice regarding method of tie down becomes a critical point in the hoisting system. (See Figs. 7 and 8.) The bending of the rope around a sill or small sheave is introducing a "weakest link" in the line. A hold down sheave with properly designed clamps, which do not distort the elements in the rope, is desirable.

We have mentioned dog-legs in relation to tie downs. Dog-legs can be put in the line in a number of ways besides wrapping around a sill. Such things as running over the line with a tractor, reel jumping off stand, rope catching on broken flanges, or being thrown out of the sheave, and around the shaft, are probably some of the more common sources for dog-legs. The results are commonly referred to as soft spots. Actually, upon close inspection, it is found that the wear is only along one side. When there is no load on the rope, the dog-leg is easily seen. Under load, the dog-leg seems to straighten out. By placing a straight edge on the back side of the dog-leg, however, one can easily see the damage is still there. It is this bend that takes the punishment, and results in the wear along the outside of

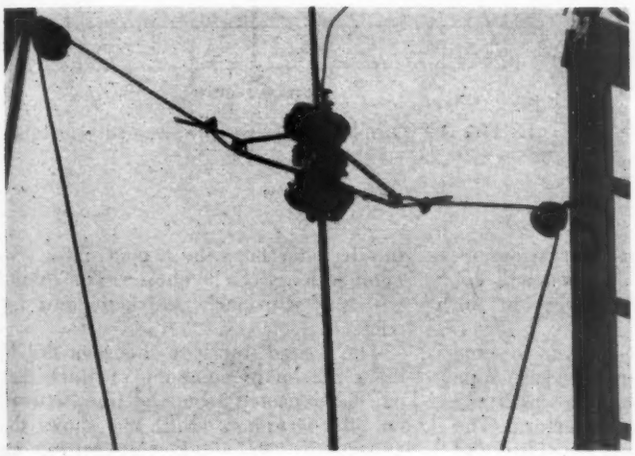


FIG. 4. Fast line wear.

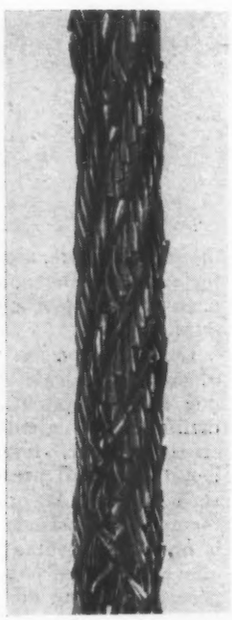


Fig. 5. Fatigue breaks. Rope should be moved more frequently.

FIG. 6. Poor hold-down practice.

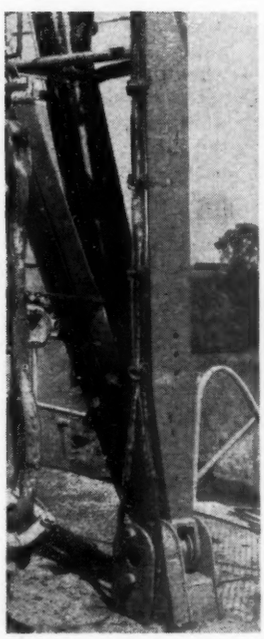
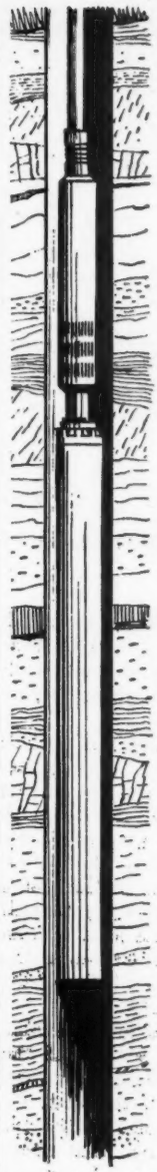


FIG. 7. Fair hold-down practice.

FIG. 8. Good hold-down practice.



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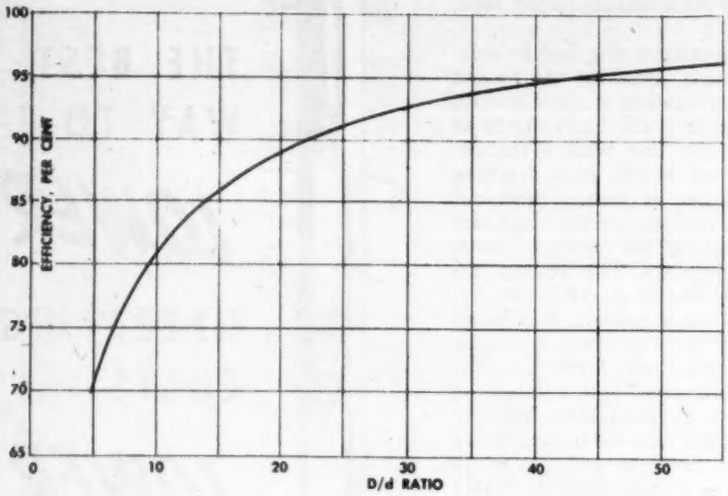

FIG. 9, Graph 1. Static efficiency, 6 x 9 IP RL Reg. Lay IWRC Ord.

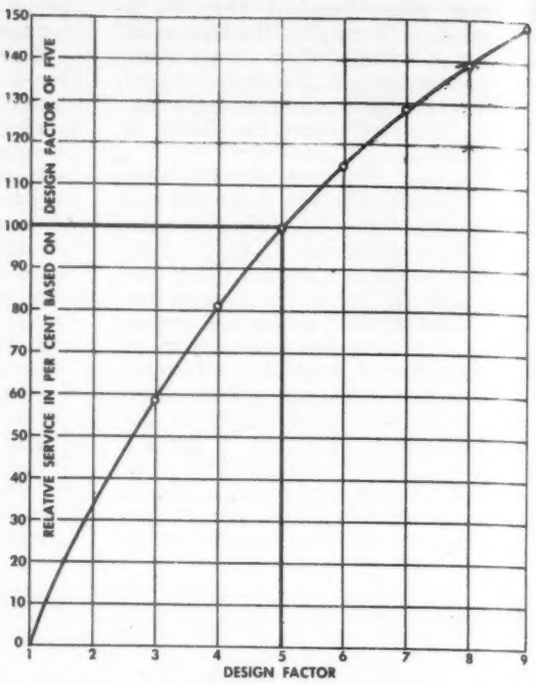

FIG. 10, Graph 2. Relative wire rope service curve.

the bend. Many units of work are usually lost when the rope is cut back to these spots, as they generally do not work completely through the reeving before the wires being to crack up.

Closely related to the bending of wire rope around small sheaves, sills, mechanical and equipment hazards, as just discussed, is the service that can be expected from a loaded wire rope. We know from experience that a line is variously loaded during the drilling of a well. Sometimes it is necessary to pull HARD; at other times the load is comparatively light. Generally though, the driller does have control of the loads that are hung on the line.

Graph 2, Fig. 10 gives us a graphic picture of the expected service of the line based on various design factors. (Ratio of rope strength to load applied.) Using the factor of 5 as 100 per cent, it can clearly be seen that dropping down to the factor of 4 reduces the service to approximately 80 per cent. Going to the factor of 6, the expected service is increased to 115 per cent. As in many other phases of analyzing wire rope performance, consideration has to be given time and costs to determine the most economical factor (expressed in number of parts of line) to use for any particular loading.

Having now briefly covered some of the more outstanding mechanics for handling, care, and maintenance of drilling lines, the actual usage of this piece of equipment will be discussed.

Usage

Up to about three years ago, the evaluation of the work done by a drilling line was an engineer's toy, to be calculated, if and when time permitted, with a few mental notes of the results. Methods of improving the ton-mile experience of drilling lines was a subject of debate with only a few scattered cases where some definite thought was put into an active program.

Today there are a number of slide rule calculators available that make the ton-mile calculation simple enough that everyone around the rig can find the answer. Although the values, as read from these calculators, are an approximation, the variables that are dropped will not make any appreciable change in the total.

Consideration has been given to some of the mechanical failures of wire rope due to the type of service which the drilling line is called on to perform. The crossover wear, vibration, crushing and bending are all present as long as the rig is running. By operating in one spot for extended periods of time, the result is undue weakening of the rope at the above mentioned points. It then becomes necessary to cut off excess amounts of line. Visual inspection is of no value, except to be advised of unexpected wire breaks or excessive wear from such things as worn sheaves, or abrasion against improperly placed equipment. In such cases, the line should be cut. Under a normal operation, however, the line should be moved before any signs of deterioration can be observed. To accomplish this, a predetermined procedure is set up, based on past experience.

To set up a procedure to be carried out, the first step is to choose a length of line as long as can be handled economically with the equipment available. The two graphs, 3 and 4 (Figs. 11 and 12), show clearly the advantage, from a ton-mile consideration, to be gained by the purchase of maximum length lines. Although these charts are theoretical, it is found that when using lines twice the length needed for reeving, or longer, a similar curve can be plotted from actual experience. On lines shorter than twice the reeving length, the curve is not accurate as more ton-miles per foot of rope can be obtained than the curve indicates. For this reason, the lower end of the curves are subject to a critical analysis. Other overhead costs, as well as handling problems, enter into the decision as to the proper, most economical length to be chosen. These costs will vary with each contractor and district.

The second step is to choose or decide on a reasonable amount of work that can be expected from the line between cut-offs. Graph 5 (Fig. 13) shows the progressive steps taken in setting up optimum values for the individual drilling conditions. This chart is a copy of a cut-off procedure that was set up for a 147-ft derrick, 4000-ft 1¼-in. rotary line with 8 parts. Seventeen hundred and fifty feet was used for stringing-up and 90 ft for each cut-off. The experience curve followed the solid lines within a reasonable tolerance. The dotted line indicates the erratic results that followed when the high work values were set up.

In choosing a reasonable amount of work expressed in ton-miles as a start, the value can best come from individual past drilling experiences. When acceptable figures are not available at this source, experiences of others under like conditions can be used. Referring again to Fig. 13, Graph 5, it is noted that the amount of work for each 80-ft cut-off was 800 ton-miles. When the program has been successfully carried through for the first line, a higher value is assumed. Repeating the procedure such as illustrated in Graph 5 a point is soon approached where the driller finds it impossible to carry out the program safely. Under these conditions, a curve is obtained that follows somewhat along the dotted line on the graph. The point is now approached where one has waited until the rope shows deterioration — a condition one is attempting to avoid.

After determining the ton-miles between cut-offs, the length of cut-off must be decided upon. Successful programs have been carried out cutting off

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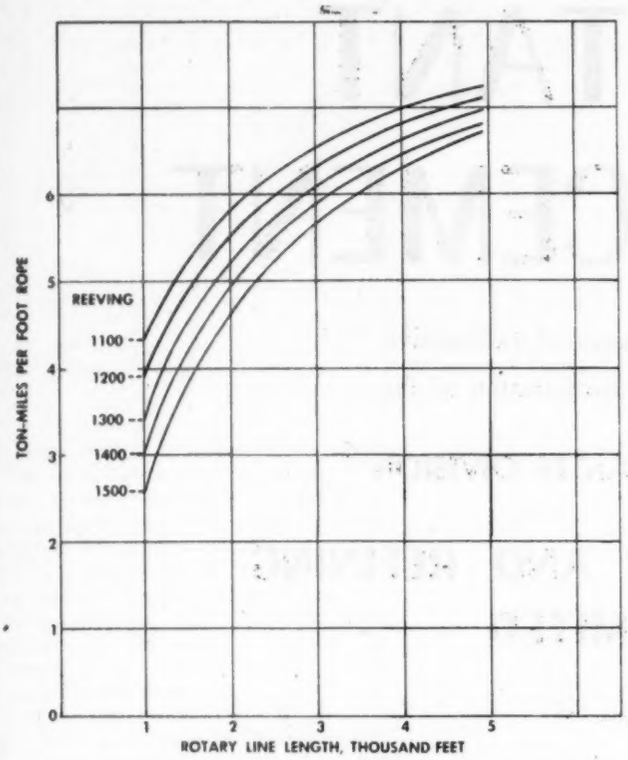


FIG. 11, Graph 3. Expected service of line. 1⅛-in. rotary mile, 800 ton miles for first cut, 700 ton miles for additional cuts, 80-ft cut-offs.

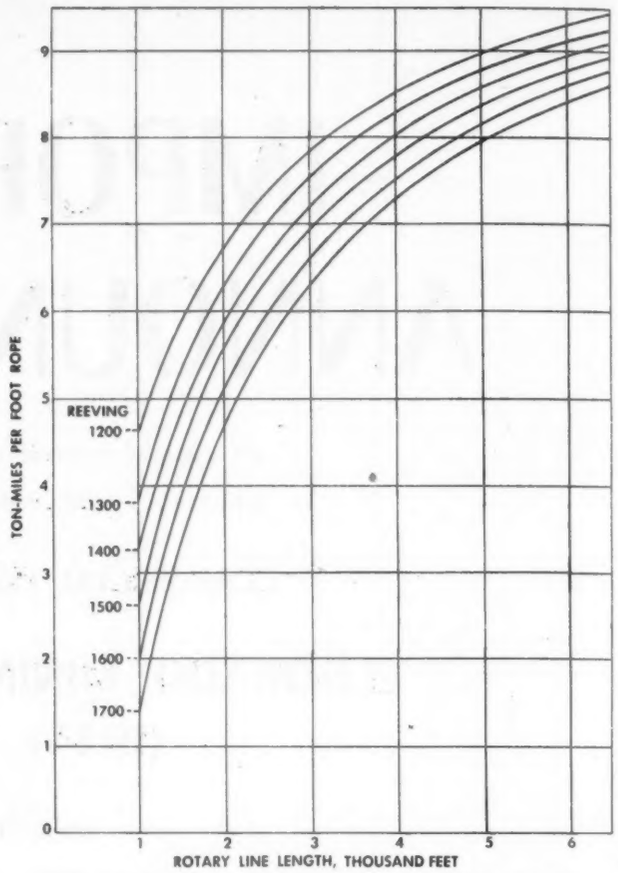
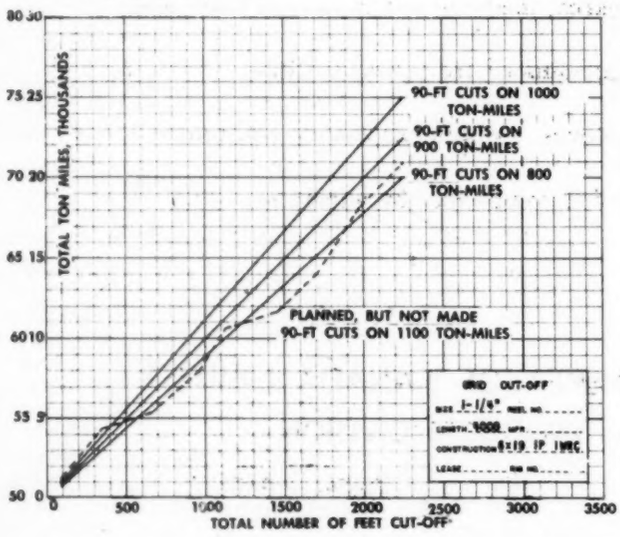
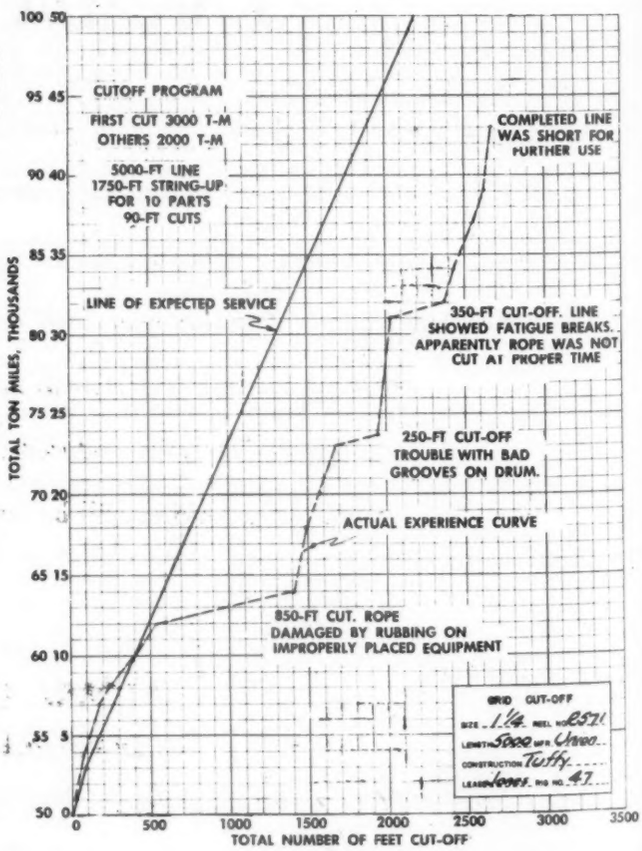


FIG. 12, Graph 4. 1¼-in. rotary line, 1300 ton miles for first cut, 1100 ton miles for additional cuts, 90-ft cut-off.

FIG. 14, Graph 6. Composite graph of field experience cut-off practice.

FIG. 13, Graph 5. Planned cut-off procedure based on work done by line.


TOTAL TON MILES, THOUSANDS
90-FT CUTS ON 1000 TON-MILES
90-FT CUTS ON 900 TON-MILES
90-FT CUTS ON 800 TON-MILES
PLANNED, BUT NOT MADE
90-FT CUTS ON 1100 TON-MILES
TOTAL NUMBER OF FEET CUT-OFF


CUTOFF PROGRAM
FIRST CUT 3000 T-M
OTHERS 2000 T-M
5000-FT LINE
1750-FT STRING-UP
FOR 10 PARTS
90-FT CUTS
COMPLETED LINE WAS SHORT FOR FURTHER USE
LINE OF EXPECTED SERVICE
350-FT CUT-OFF. LINE SHOWED FATIGUE BREAKS. APPARENTLY ROPE WAS NOT CUT AT PROPER TIME
250-FT CUT-OFF TROUBLE WITH BAD GROOVES ON DRUM.
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TOTAL TON MILES, THOUSANDS
TOTAL NUMBER OF FEET CUT-OFF

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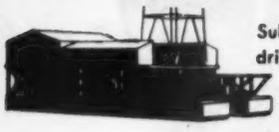

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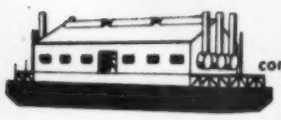

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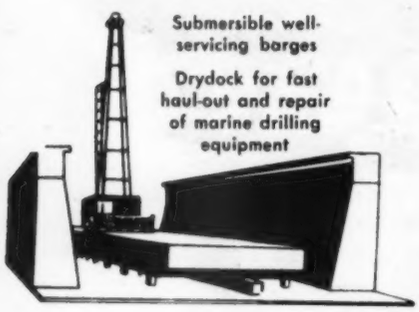

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from 30 to 150 ft. There may be some local reason for either end of this range. From field experience a length of rope equivalent to the distance the blocks travel from pick-up to up position seems to be satisfactory for most applications. For convenience on the rig, this length can be expressed in turns or wraps on the drum.

At this point it is advisable to add an extra one-half wrap so as to move the crossover and pick-up points around on the drum.

The frequency of cut-off is automatically taken care of by this procedure. Care should be exercised, however, as to the frequency of shut down for cut-offs. If short lengths are cut off, the frequency increases, thus drilling costs are increased. To overcome partially too frequent interruptions of drilling for cut-offs, many contractors have resorted to slipping their line 2 or 3 times before each cut. There seems to be a number of field experiences both for and against the practice. At this time it is believed to be strictly a company practice, as the field data available do not warrant a definite universal stand for the practice.

Long columns of figures tabulated in the log books are generally very uninteresting, and many times significant facts are overlooked. These facts can, many times, indicate cause of premature failures, sub-standard equipment or methods. By translating the data into a picture, one can readily pick out the soft spots in any operation. Graph 6 (Fig. 14) is a composite graph of actual field experiences where an attempt has been made to set up a cut-off procedure. It is interesting to note that it was fairly easy to meet the planned program as long as "accidents" didn't happen. When trouble was encountered, an excessive amount of rope was cut off, causing a loss of ton-miles. Some of the accidents were unavoidable, others were caused by carelessness.

As a result of a careful study of these experience curves, changes were made in the instructions to the fieldmen, with the result that subsequent drilling lines gave 40-50 per cent more ton-miles. The drillers became more familar with the problem, and made a greater effort to avoid bad habits. It is interesting to see how fairly easy the job becomes to follow the line of expected service.

Care, accompanied by know-how in the way a job is done always results in the saving of time, money, and material. This is especially true when a wire rope drilling line is used. With the advent of deeper drilling, the use of more drill collars, higher speeds, and the other accompanying drilling conditions that throw more demands on a wire rope as an everyday practice, it now becomes imperative to recognize the need for the elimination of haphazard methods and guesswork. Greater attention must be paid to basic principles, to insure maximum, safe, and economical rope service in reaching these deeper horizons. * *

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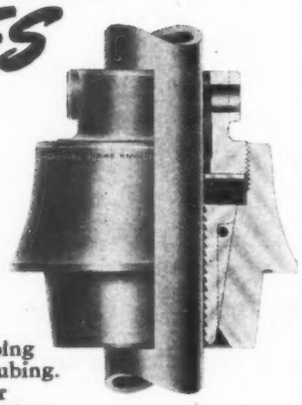

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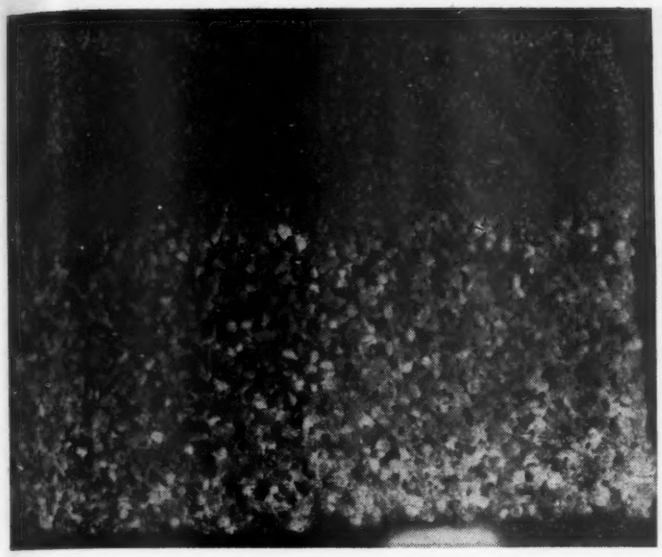


FIG. 1. Photomicrograph shows how a properly selected gravel pack prevents sand from entering well. In laboratory experiment sand was poured on top of gravel and fluid was then forced down through sand and gravel.

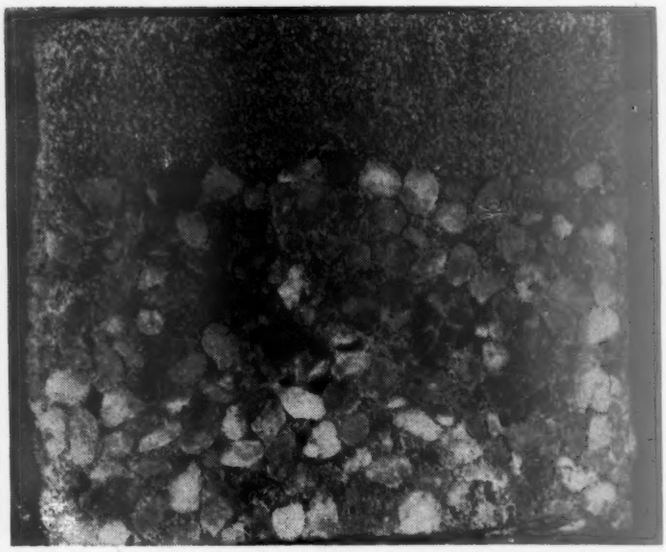


FIG. 2. This photomicrograph shows how sand will invade a gravel pack when gravel grain size is too large.

The ABC's of Sand Exclusion

One of oil man's toughest production problems is keeping sand out of well bore while allowing the oil to enter

RICHARD SNEDDON*

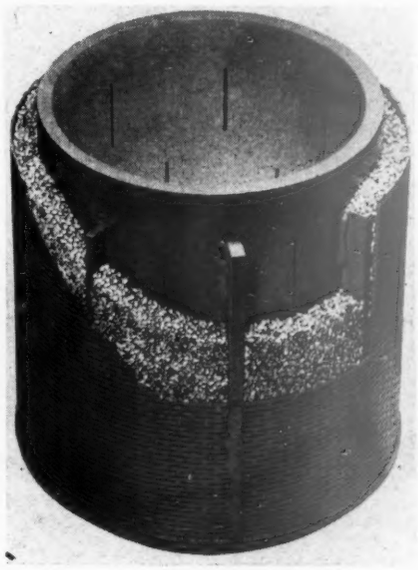
In its earliest beginnings the production of petroleum was a distinctly haphazard sort of business, and many of its processes and devices were certainly not based in the sanity of science. Down through the years, however, the competitive urge has spurred operators to more and more critical analysis of their own tools and techniques; the extent to which they perform their basic functions, and the manner in which their performance might be improved. The inevitable result of all this is that today it is practically impossible to find a piece of equipment or an obscure operational technique that has not been developed along the most logical lines and subjected to the most meticulous testing.

One of the tougher production problems that has received a fair share of research is the selection of the most efficient device or technique that will keep sand out of the well bore and yet allow oil to enter. It is the purpose of this article to present some aspects of the problem and to discuss some of the basic theories that have been developed concerning sand control measures.

In those oil fields where the producing zone consists, either totally or in part, of fine, unconsolidated sands, it is natural to expect high maintenance costs because of abrasion, plugging, casing collapse, and many other contingent developments that interfere with orderly maximum depletion of the drainage area of the well. There are a number of oil fields that are characterized by loose, poorly compacted sands of this type, and in some of them the adequate exclusion of sand is an absolute essential of profitable operation. Unconsolidated sands are, as a rule, of relatively recent geological age, and as their deposition is normally also of unusual thickness, oil production is decidedly complicated by the sand problem. A classic example is the Wilmington field in California, which has a number of producing zones that are characterized by great thickness, lack of consolidation, and a tendency to heave during drilling and clean-out operations. Needless to say, the economic production of this field presents a real challenge to the ingenuity of the engineers and technologists.

It is no wonder, then, that the whole matter of sand exclusion has been the subject of intense study for many years and that its involved factors and phases have been searchingly examined by a long succession of production engineers. The three principal methods by which the entry of sand into the well bore may be limited are (1) the employment of slotted liners, (2) the pumping of gravel packs behind liners in place, and (3)

FIG. 3. Cutaway section of a prepack gravel liner showing slotted liner, gravel sheath, and retaining screen. In actuality, all slots are covered by the gravel sheath.



*Pacific Coast Editor.

EXCLUSIVE

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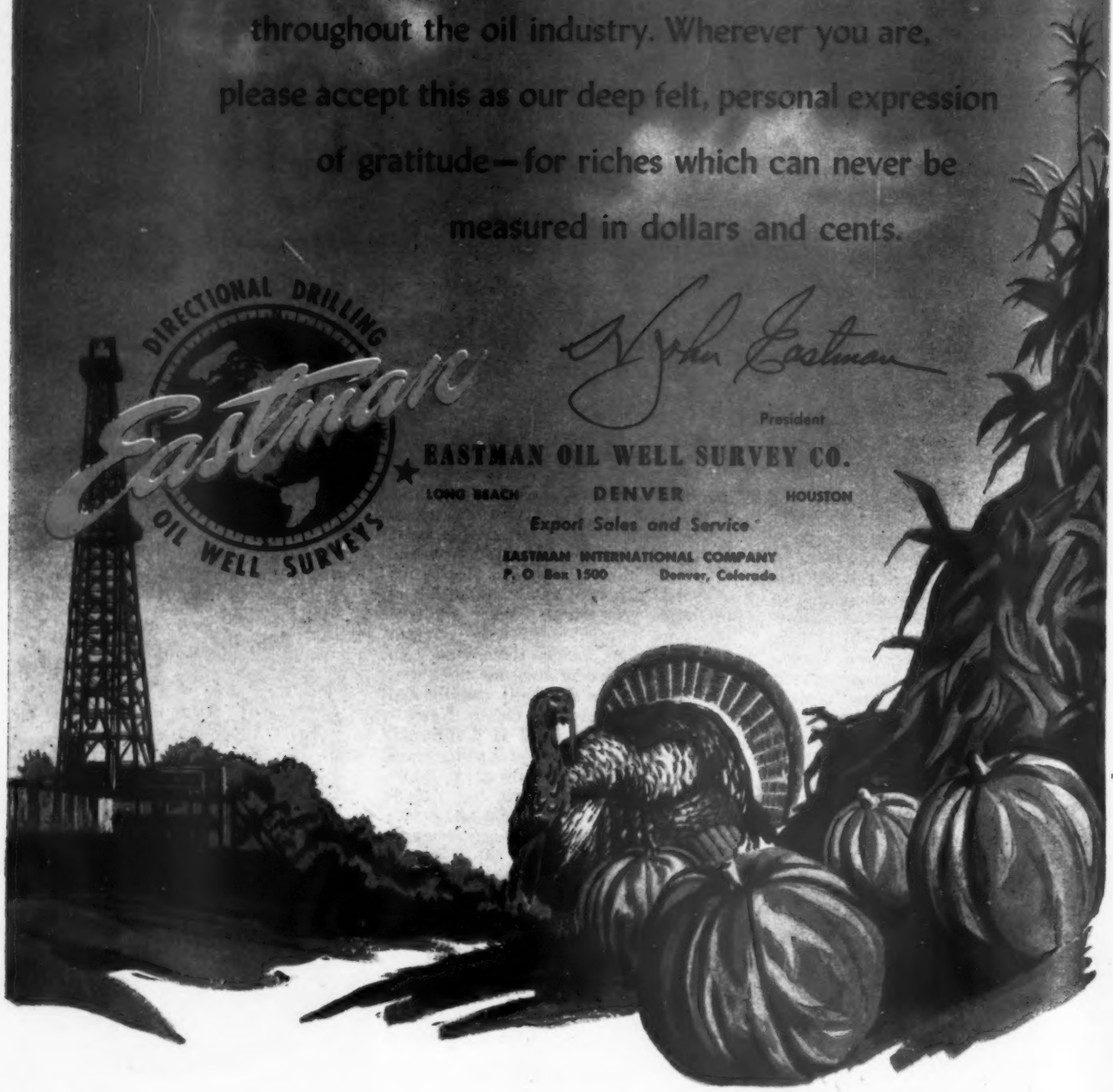

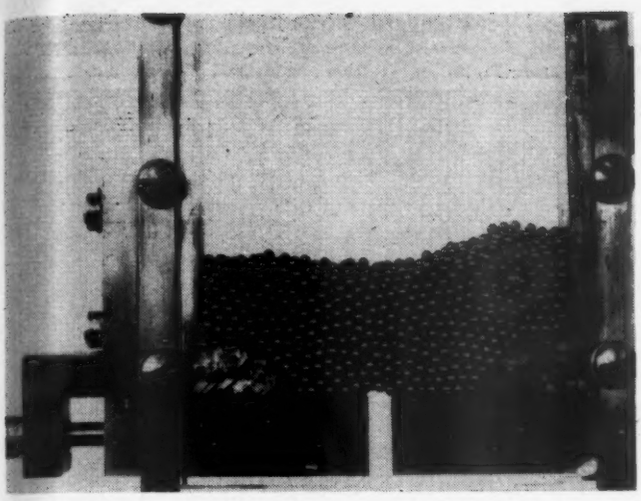

FIG. 4. Laboratory device used to determine slot sizes required to prevent sand incursion. This demonstrates how steel balls will form a bridge over a slot twice as wide as slot diameter.

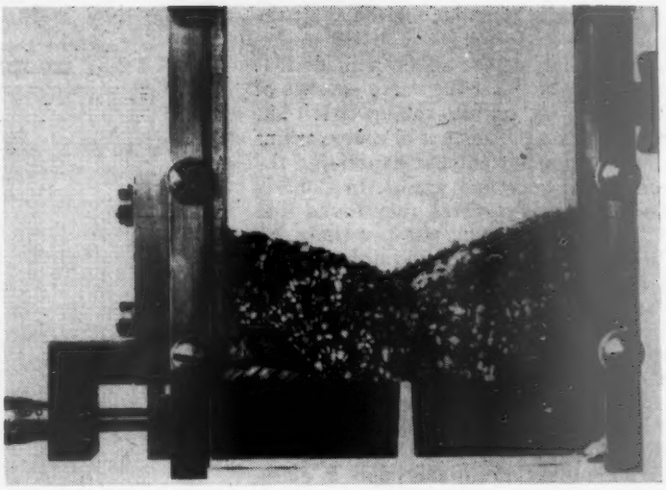

FIG. 5. This is the device used to show how irregular grain shapes will bridge over an open slot if the slot width is not more than twice the grain size.

the utilization of prepacked liners. It is the purpose of this article merely to present a brief review of the background work and the purposes and value of these methods. This, of course, is by no means the last word on the subject. As a matter of fact, on certain phases of the general study, the various authorities on sand exclusion are not themselves in agreement, and this author would certainly not presume to arbitrate the points at issue, so where necessary such differences will merely be stated and not debated.

Concerning the slotted liner, some interesting research on the slot-width-grain-size relationship was conducted by C. J. Coberly[1] about 25 years ago. Beginning with steel balls of uniform diameter, he sought to establish a relationship between the ball diameter and the widest slot that would prevent their free passage under the force of their own weight. He discovered that the greatest slot width over which a stable and predictable bridge could be formed was twice the diameter of the balls. With slot widths between 2 and 2½ times ball diameter, bridges formed, but they were unstable and failed under slight disturbances. With slots over 2½ times ball diameter, flow through the slots was continuous.

With these facts established, Coberly and Wagner[2] later reported having found that clean sand grains of uniform diameter behaved very much in the same manner as the perfect spheres regardless of how assymetrical or angular the grains might be. Dry sand bridged a slot the width of which was twice the grain size, and when a fluid was passed through the sand and slot, none of the sand grains were carried through as long as the pressure imposed was not over 1000 psi. That was a very important discovery, and, as usually happens, it led to other important discoveries.

The next step was to determine what happens when the sand is non-uniform as to grain size, which, of course, is the common circumstance; and here it was found that bridging was controlled by the proportion of large grains. To understand the method of measuring the grain distribution within a core sample, it is necessary to be familiar with the Tyler method of analysis. The procedure consists of pouring the entire sand sample into the top member of a series of nested screens. The top screen has the largest opening, the second screen is a little smaller, etc., down to the bottom, which is a closed pan. The whole nest is shaken and tapped for a given length of time in a special machine made for the purpose. Then the nest is broken apart, and the amount of sand retained on each screen is weighed. To get a visual expression of the distribution of sand grains, these weights are plotted accumulatively on a Tyler chart. This chart consists of a vertical scale which expresses accumulative percentages as a linear function, and a horizontal scale which expresses screen size openings as

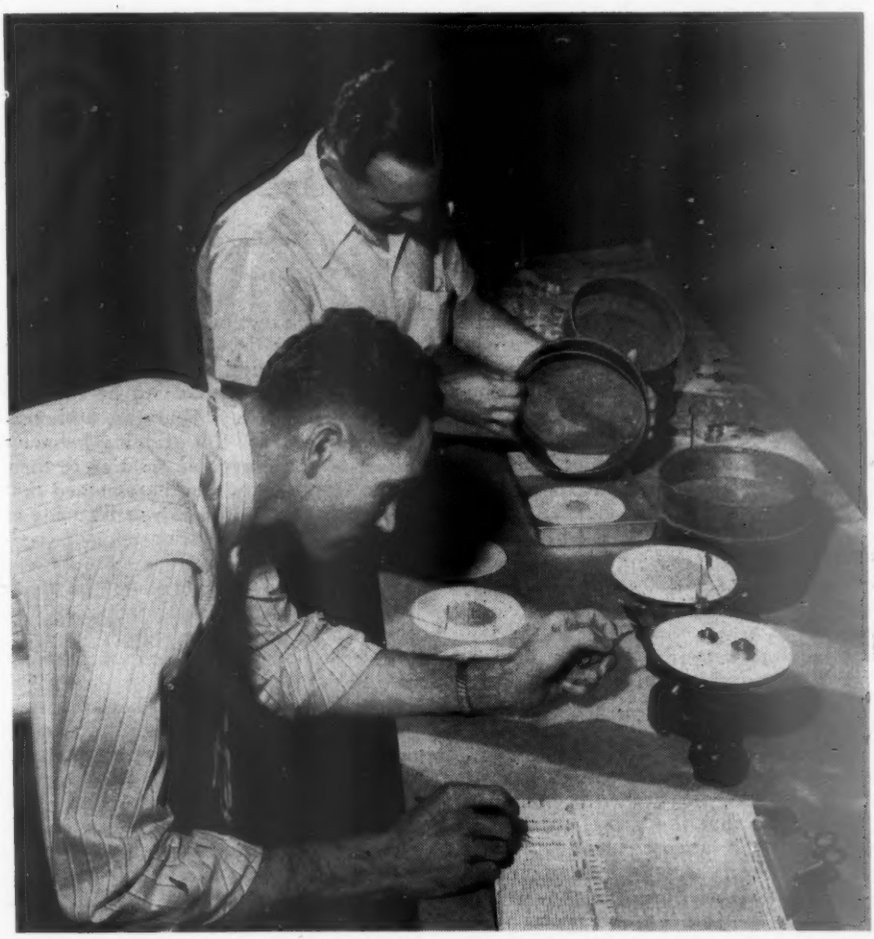

FIG. 6. Tyler screen analysis of core sand is required in design of liners for sand control in oil wells. Laboratory technicians are here seen weighing residues on the nest of Tyler screens and charting results.

a logarithmic function. On the chart the screen sizes decrease to the right so that when a plot of the sample is made it is typical to find that the curve consists of an elongated "S" with the lower left bar representing the amount of coarse grains and the upper right bar expressing the amount of very fine grains. In Coberly and Wagner's research they found that a slot opening which was two times the 10 percentile size of the sample was the largest that could be depended upon to cause a stable bridge to prevent sand from flowing through. This size designation, of course, means that 10 per cent of the sample was larger than the mesh size selected to cover the slot opening and 90 per cent of the sample was smaller than that mesh size. In watching the action of the grains through a glass-sided device, the researchers noted that a small amount of sand would start flowing when the sample was first put in, but large grains would soon come together and form the bridge, thereby holding back the rest of the sample. It was during these tests, too, that Coberly and Wagner found that it was important that the slot be undercut so that any sand that passed through the initial opening would not be able to jam within the walls of the slot.

This theory concerning the relationship between slot size and sand grain size has been proved applicable in those cases where it is practical to use slots. In some sands, however, the sand analysis indicates that the 10 percentile size of the sample is so small that it is not practical to cut a slot to keep the sand from coming in. For this circumstance it has been known that a gravel sheath will afford the needed protection, and Coberly and Wagner have done much of their research on the dimensional relationship between gravel size and grain size needed for an effective gravel pack.

In this instance, too, the researchers started out with perfect spheres to get some general dimensional relationships and then progressed to actual materials. It was a relatively simple matter to calculate that when the spheres were arranged in a hexagonal pattern, the space between them, i.e., the interstices, would consist of an opening that would bound a circle with a diameter of approximately 1/6th of the diameter of the spheres that formed the interstices. Using the dimensional relationship established with the slot, you can consider that the maximum opening in the interstices is a controlling dimension for the passage of grains, and arrive at the following dimensional relationship: The sphere required to provide an interstice to control a given sand is one with a diameter that is not more than 12 times the 10 percentile of the sand sample. Subsequent tests with actual gravel, which was carefully graded to minimize flats, proved that the gravel would act in a manner almost identical with spheres. Coberly and Wagner suggested that a reasonable dimensional relationship would indicate that if a gravel pack were used, the gravel size should be 10 times the 10 percentile of the sand sample.

Although there are divergent opinions

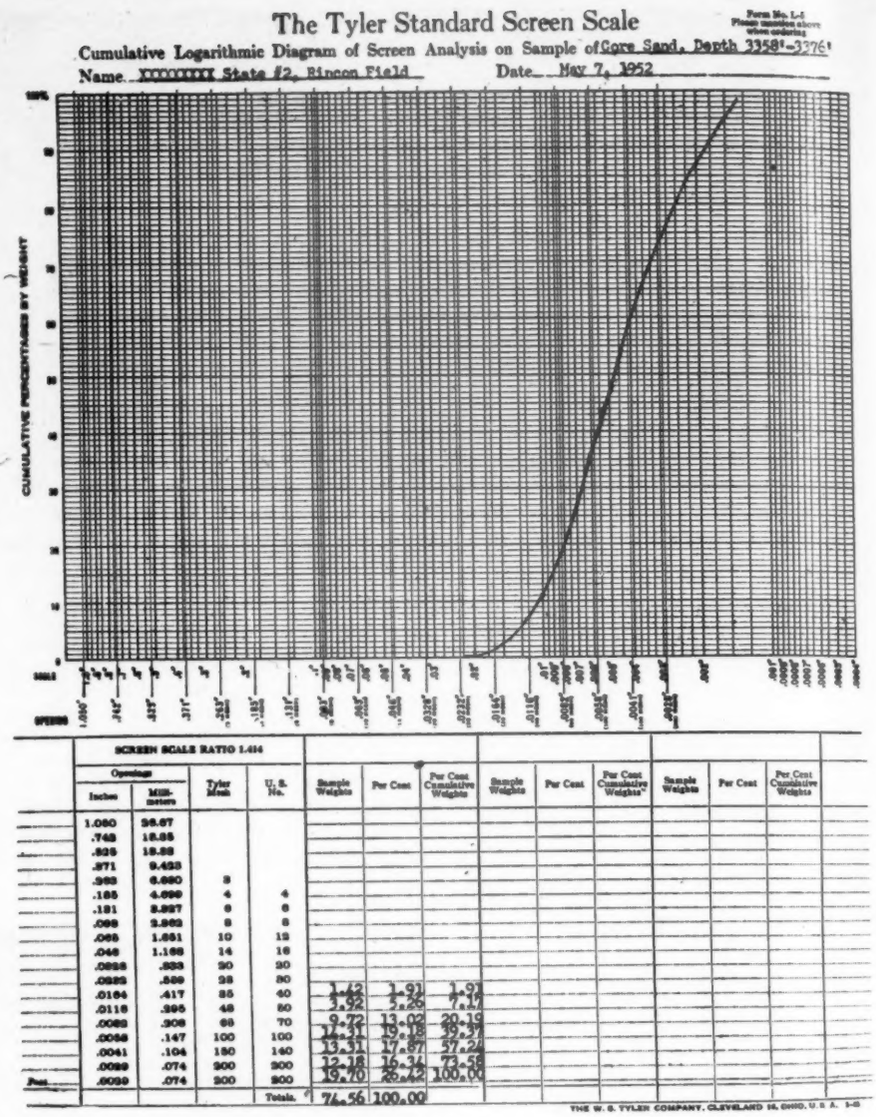

FIG. 7. Tyler Standard Screen Scale and a plot of an actual core sample.

about the exactitude of some of the figures so far developed, they nonetheless are the basic factors that enable the sand exclusion problem to be handled in a scientific way. Knowing with reasonable accuracy the bridging behavior of sands and gravels in relation to their grain size, it may then be assumed that if an accurate grain analysis be made of the producing formation in any well that derives its flow from more or less unconsolidated sands, it should be possible to determine the exact size of the slot or other apperture required to keep the loose, fine material from passing into the well bore.

It is to be remembered, however, that the analysis of a core sample, after it has been brought to the surface, may not represent its true characteristics as they exist at the face of the liner. The physical relationship between grain sizes may be altered by the leaching effect of formation water or the action of drilling mud under high pressure. The chemical character of the matrix may be changed by interaction with additives, and a score of other agencies and influences are constantly threatening to confuse an already confused issue. Any action, for instance, that might change the 10 percentile of the sand would also alter the calculated slot size of the liner to be used, or the grain size of gravel. It thus becomes essential that all pertinent conditions be thoroughly understood and that they receive proper consideration in the production plan.

Regardless of these drawbacks, core grain analysis certainly remains a logical base for an intelligent handling of the sand exclusion problem, and in spite of its margin of error, it is in the long run infinitely better than the luckiest guess. It is true, as Hill[3] pointed out, that the curve indicating the cumulative weights of various sand sizes does not reflect the frequency of any one size of grain and that a low gravel-sand ratio should be assumed when dealing with sands that have a high incidence of small grains. With the absence of absolute data, it is never possible to develop an absolute remedy, but the weighing of such data as are available and their intelligent evaluation can often spell the difference between successful operation and abandonment.

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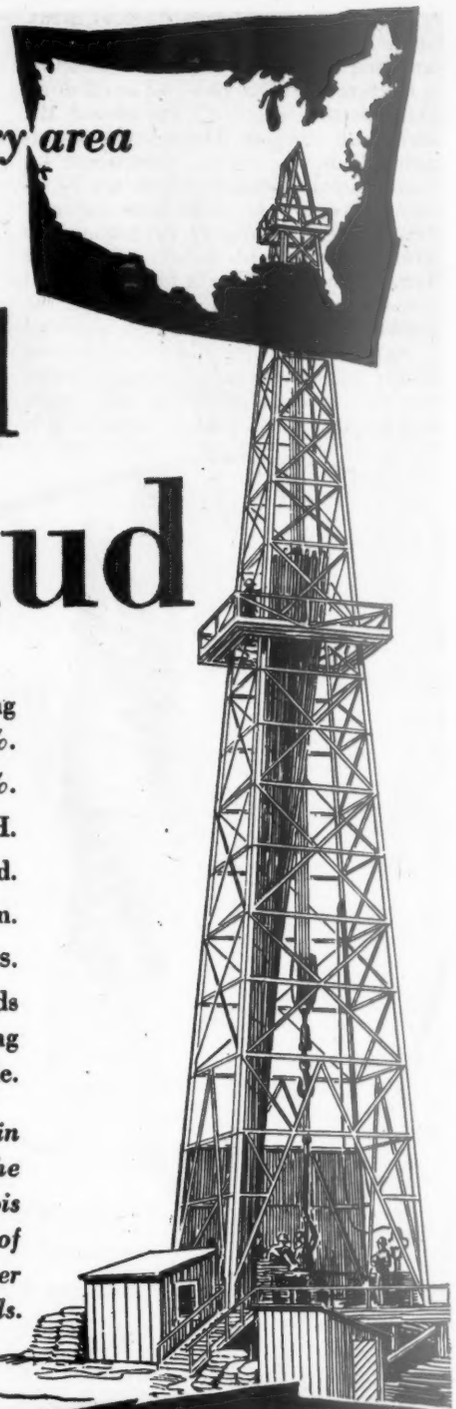

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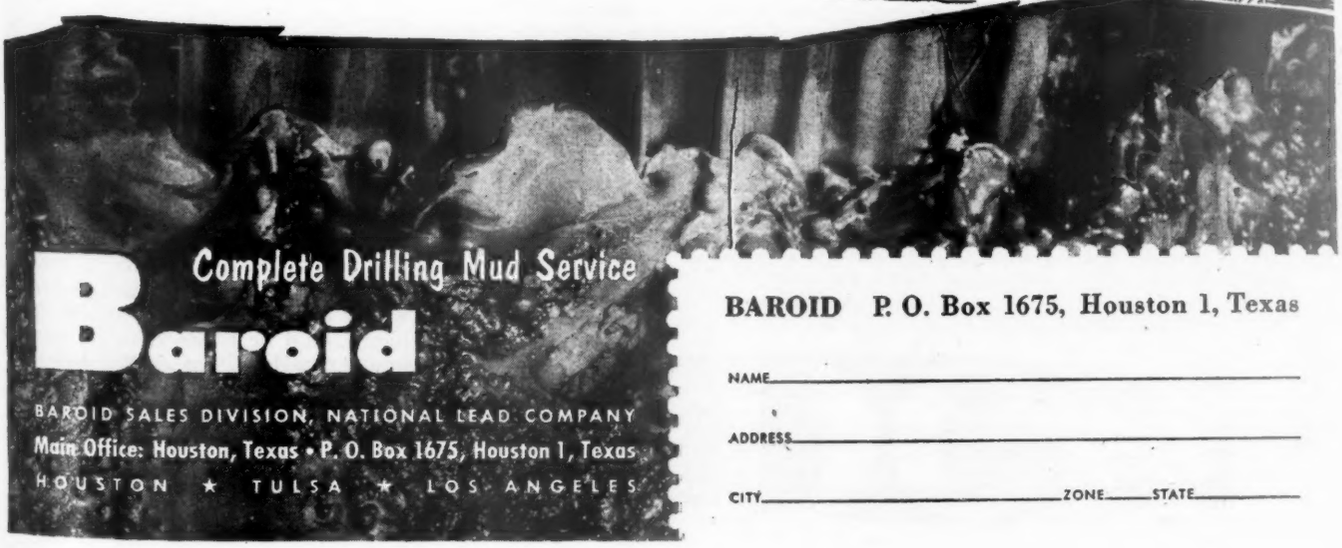

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gravel to the prevention of sand incursion. One of the earliest applications and one still in use is that of pumping a mixture of gravel and mud or oil down through the liner and up around the well bore annulus. The success of this method is, of course, contingent on many factors, some of which are by no means easy to control. Its main difficulty lies in the uncertainty of getting the gravel evenly distributed behind the liner. If the well bore is irregular, or if the liner is not properly centered, the thickness of the gravel sheath is bound to vary accordingly, and a thin section at any point may cause the fluid to enter the well at high velocity at that point and to carry sand through the pack. It is also possible for the pack to settle unevenly in time, leaving exposed areas of the liner to direct sand intrusion. On the other hand, where an even pack of the right thickness and correct gravel size can be maintained without interruption, the pump pack should perform its function adequately.

To overcome the problems encountered in trying to use the gravel pack there are a few manufacturers who provide a prepacked gravel liner. Typically, this assembly consists of a slotted liner with ribs welded on it which in turn has a perforated steel sheath welded to the ribs. This forms an annulus between the sheath and the outside of the liner and with the bottom of the annulus sealed with a welded ring, proper size gravel is poured into the annulus and shaken down until it is tightly compacted. After the gravel is in place and covers the top perforations, the pack is sealed by welding the annulus shut at the top. This provides a sheath of gravel around the liner and the operator can be certain when he lowers it into the well that the gravel will stay in place as long as the liner is intact.

Various individuals have attempted to evaluate the effectiveness of these sand control measures. Read Winterburn[4], in a study of some 260 wells in the Wilmington, California field reported that almost complete effective control of the unconsolidated sand of the Tar, Ranger, and Upper Terminal zones had been accomplished in wells equipped with prepacked liners using gravel ranging from .693 in. to .131 in. in diameter, or gravel packed liners using gravel of .131 to .187 in. or smaller. He further concluded, however, that plugging of gravel packs and prepacks caused a more rapid decline in productive index than that which occurs when conventional liners are used, although the former result in greater economic returns during the early history of the well because of the higher rate of production without sand trouble and consequent lower production costs.

Based on a 7½ year observation period, Winterburn notes that the average well using gravel produced 20 per cent more oil than the average conventionally completed well, and the average maintenance cost for the period on the gravel screened wells was $1000 as compared with $8000 for the conventional well. The author points out, however, that while on the basis of the 7½ year period, the economics of the situation are all in favor of gravel screening, nevertheless with typical scientific cautiousness, he is inclined to produce the zones in question to depletion before coming to any further drastic conclusion. It is interesting, also, to note Winterburn's statement with regard to grain size and sand control, which was as follows: "Actual experience in the field has shown that sand entry can virtually be eliminated by use of a gravel, the finest 50 per cent of which is approximately 10 times the grain size at the 10 percentile of the finest sand to be screened."

William Ross Cabeen and Edwin G. Bemis[5] two years later prepared an exhaustive report on the performance of various types of sand control liners in California. These authors compared the production performance of 769 wells, including approximately one-third of the total wells in the state completed with gravel pack liners of each generally recognized type. They found that slot widths and gravel sizes of sand control liners could be adjusted to obtain virtually complete sand control and that liner failure is at a minimum when nearly complete sand control is obtained.

The examination indicated that conventional slotted liners imposing no sand control had high production perform-

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ance, but cleaning and redrilling costs made their use in most instances uneconomical. Conventional slotted liners imposing partial sand control exhibited the second highest production performance, but at the cost of cleanout and liner failure that made them less attractive, economically, than gravel pack liners. Pump-pack gravel liners were third high in production performance with fewer liner failures than the foregoing, but more than pre-pack gravel liners. The latter showed the lowest production performance of all, but also involved the fewest liner failures. The problem, thus, would seem to resolve itself into one of striking an optimum relationship between the degree of sand control and the economic aspects of the particular medium employed to control it.

It would hardly be appropriate in this article to dilate on the relative merits of torch-cut and milled slots; to compare the virtues of slots and circular ports, or to discuss the varied geometrical arrangements of slots and ports. But these matters, too, have been the subject of much independent and cooperative research, and the results are available to anyone sufficiently interested to run them down. Certain it is that sand incursion, with all its unpleasant and expensive concomitants, has been and is being tackled in a completely rational manner. The field investigations to which reference is made here are still going on, and more and more pertinent data are being accumulated. Up to the moment it would seem that the three most effective methods are the use of prepacked liners, pump packed liners, and conventional liners, all, of course, based on grain size tests of the producing sands. It has been thoroughly established that the exclusion of sand cannot be intelligently contrived without accurate foreknowledge of the character of the producing sands.

This writer has long scanned the ways of the oil men for some haphazard function or operation that has just been passed down by their predecessors and has been accepted without question because it works. We find, however, that oil operators are confirmed skeptics who accept nothing without satisfying themselves that it is founded in logic and that it performs a desirable function adequately. The search for the haphazard has so far been unavailing, and now there is no recourse but to admit that even slotting is scientific.

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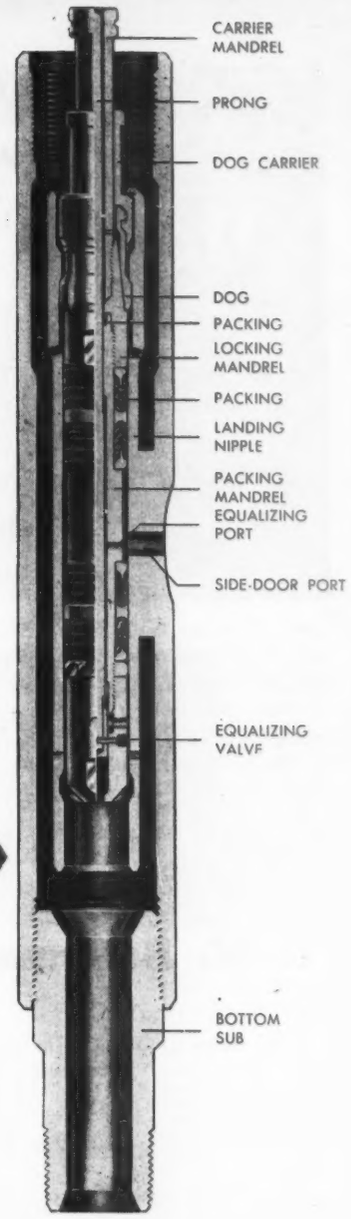

Type A Otis Side-Door Choke

The Type A Otis Side-Door Choke and Landing Nipple assembly is a new Otis dual-completion tool that provides maximum flow capacity, and is especially suited to formation-fracturing and other similar well completion operations. A new design, consisting of a landing nipple mounted concentrically within an outer flow sleeve, allows the assembly to perform all of the various functions of a conventional Otis Side-Door Choke and Landing Nipple assembly, without restricting the flow to the bore of the choke. The large by-pass area around the seating nipple provides a flow course of more than two square inches for full production through the tubing, or for acidizing, conditioning mud, taking bottom-hole pressures, and various other operations. The new Type A Choke also has a built-in equalizing device to facilitate pulling the tool in the event unbalanced or packed-off pressures prohibit full equalization across the tool. Inasmuch as the seating nipple is independent of the tubing nipple, the same choke can be run in either a 2" or 2½" string.

This new choke assembly is another Otis tool that affords exclusive applications not available in any other production equipment on the market. If you want a better way to get better production from your operations, ask your nearest Otis office, or contact us in Dallas, for full details on this and other Otis single- and two-zone production equipment. There's no obligation, of course.

PRESSURE CONTROL OTIS SERVICE - EQUIPMENT

OTIS PRESSURE CONTROL, Inc.

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DALLAS . HOUSTON . CORPUS CHRISTI . LONGVIEW . VICTORIA . FALFURRIAS
ODESSA . NEW IBERIA . SHREVEPORT . HOUMA . OKLAHOMA CITY . ELK CITY

New officers of AAODC are: *Seated,* J. W. Hall, vice president, West Texas and New Mexico; Stuart G. Noah, vice president, Illinois, Michigan, Indiana, and Kentucky; C. F. Whaley, vice president at large; A. W. Thompson, immediate past president; F. W. Brigance, president; Brad Mills, executive vice president; and Earl C. Flesher, vice president, Central Mid-Continent area. *Standing,* H. H. Hillman, vice president for well servicing; John M. Grant, vice president, California; K. L. Kellogg, secretary; Marion S. Church, general counsel; Louis A. Beecherl, treasurer, and John B. Holmes, vice president, Gulf Coast. Officers not shown were: Harold H. McClure, vice president, cable tools; N. H. Wheless, Jr., vice president, cretaceous and tertiary basins; and Walter C. Tschudin, vice president, Rocky Mountains. A resolution was adopted commending past president, A. W. Thompson.

F. W. Brigance Is New President of AAODC for 52-53

F. W. Brigance, Rowan Drilling Company, was named president, 1952-53 for the American Association of Oilwell Drilling Contractors', at the 12th annual meeting in Oklahoma City, in September.

Vice presidents are: C. F. Whaley, Chet Whaley Drilling and Well Service, at large; J. W. Hall, Trinity Drilling; Harold H. McClure, Jr., McClure Drilling, cable tools; John B. Holmes, Holmes Drilling, Gulf Coast; Earle C. Flesher, Johnson and Flesher, Central Mid-Continent; John M. Grant, Loffland Brothers, California; Stuart G. Noah, Noah Drilling, Indiana, Illinois, Michigan, and Kentucky; N. H. Wheless, Jr., Wheless Drilling, Cretaceous and Tertiary Basins; Walter G. Tschudin, Pioneer Drilling, Rocky Mountains, and H. H. Hillman, California Production Service, well servicing. Other officers include: Louis A. Beecherl, McDaniel and Beecherl, treasurer; Brad Mills, executive vice president; K. L. Kellogg, K. L. Kellogg and Sons, secretary; and Marion S. Church, general counsel.

The morning session of the first day, September 29, was devoted to various committee meetings. Appropriate sizes of drill pipe for particular areas, requirements of a drive for a mud pump, and the merits of certain drilling fluids were considered, and the possibility of having a standardized drilling report was proposed.

Governor Johnston Murray, Oklahoma, made the opening address at the luncheon the first day, and in the general afternoon session A. W. Thompson, retiring president, gave a review of the history of the oil industry and the progressive part of drilling contractors in oil development. Thompson stated that "education is the chief Association function." He suggested that the Association go ahead with present useful projects, whether they be human or technical, and to promote the drilling industry as a progressive one. A suppliers' party was given at the Oklahoma City Country Club that evening.

Presentation of technical papers continued through the second day with W. H. Carson, dean of college of engineering, University of Oklahoma; W. F. Bates, Shell Oil, Los Angeles; Jack N. Yetter, Twin Disc Clutch, Tulsa, Oklahoma, and Earl Hellums, Cron and Gracey Corporation, Houston, Texas, presenting papers of interest to the drilling operator. In the evening a banquet was held. W. C. Whaley, president, Sunray Oil Corporation, was the speaker, introduced by C. W. Wright, chairman of the board, Sunray.

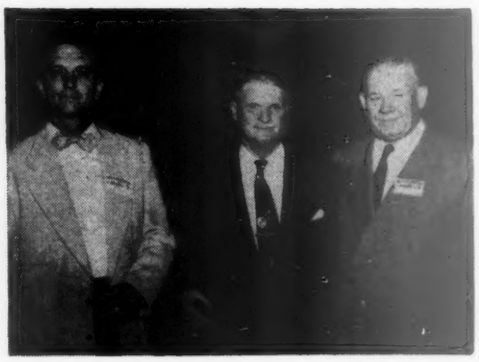
W. C. Whaley, president, Sunray Oil Company, in a banquet address before the AAODC, stated that "from a beginning that was none too auspicious the drilling industry is today organized, stable, and dependable." He commended

First photo at left: Truman Spain; R. C. Tucker, president, Great Western Drilling, Lubbock, Texas; Mrs. Tucker; Vernon Nelson. *Second photo,* John V. Eakin, Fawick Airflex, Cleveland, Ohio; Ray Loudenbach, Unit Rig, Dallas; C. F. Southward, Unit Rig, Odessa, Texas; and Kent Riley, Fawick Airflex, Fort Worth, Texas.

. . . . . STANDARDIZED DRILLING REPORT PROPOSED AT AAODC MEET

First photo, Earle C. Flesher, Oklahoma City, vice president, and J. Doyle Settle, Dallas, secretary, AAODC. *Second,* Thomas Pennington and William F. Shelton, Humble Oil, Houston; George H. Moore, Magnet Cove, Houston; and Don E. McMahon, Nicklos Drilling, Houston. *Third,* J. T. Calnon and Mr. Doxi, Cummins Engine, Fort Worth, Texas.

First photo, J. W. Gardner, Delta Gulf Drilling, and Mrs. Gardner, Dallas, Texas. *Second,* D. E. McMahon, president, Nichlos Drilling, Houston, and Ralph Neuhaus, general sales manager, Cameron Iron Works, Houston. *Third,* G. W. Walton, Ideco, Dallas, and Mrs. Otto Hamer, Whittier, California. *Fourth,* J. E. Warden, National Supply, Wichita Falls, Texas, and Tom Raney, Thompson Drilling, Dallas. Attendance was set at 1238, a new attendance record over any previous convention.



First photo, Abbott Sparks, The Petroleum Engineer, Dallas; Walter Helmerich, vice president, and Dee Sikes, contact executive, Helmerich and Payne, Inc., Tulsa. *Second,* Fern Wagner, American Iron and Machine Works, Oklahoma City, and Shirley Miller, Shirley Miller Drilling Company, Midland, Texas. *Third,* Jorda N. Terrell, Crenshaw Sales Company, Houston; J. I. Hill, Zephr Petroleum Company, Oklahoma City, and Odus Gardenshire, American Iron and Machine Works, Midland.

At the AAODC convention were, beginning far left: H. D .Powell, Mrs. Will I. Willis, Mt. Vernon, Illinois; Mrs. Pat Kennon, Oklahoma City, and Jerry Coons, Tulsa, Oklahoma. *Next,* R. Cotton Makin; Mrs. Makin; R. M. Flippo, and Tom Tucker, Emsco Derrick, Houston, Texas.

For every mud program ... specify

PB MUD GUNS

For over 14 years PB Mud Guns have consistently met exacting mud control requirements. Low in first cost... economical to maintain... absolutely non-spin and non-freeze in operation, they're factory tested to 200% rated pressure for added safety. PB Mud Guns give safe, efficient and trouble-free gunning in mud pits or tanks—whatever the pressure and volume requirements of your mud program.

Heavy Duty Mud Gun Muddler

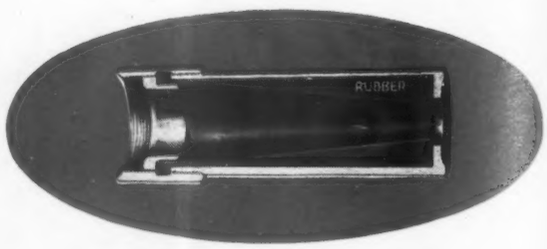
MUDDLER is an all purpose gun for any mud mixing job found in the oil fields. It can be adjusted and locked in any position from horizontal to vertical flow for complete adaptability to tank or pit type agitation. Dual mixing chambers efficiently disperse mud conditioning materials. Flexible and easy to operate – even under high mud pressures – with chrome faced packing glands to minimize friction and add life to packing. Lubricated through grease gun fittings.

General Utility Mud Gun Midlean

MIDLEAN is a moderately priced high-pressure type mud gun. It offers many of the features found in more expensive guns, and is practical for most installations. The curved neck efficiently mixes conditioning materials into the mud, but will not impede mud flow from inlet to nozzle. MIDLEAN locks in both horizontal and vertical planes for unattended jetting into pit or tank.

Bottom Type Mud Guns

MUREX is a single nozzle tank side mud gun which is frequently used in series with other guns in elongated tanks. It is adaptable for jetting at any height inside open or covered tanks. MULTURE, not shown, is a bottom type gun for center tank operation in storage tanks where mud will remain idle for a period of time. Opposing PB Nozzles uniformly mix large volumes of mud.



PB Mud Gun Nozzles

Rubber-Lined Nozzle RUGBY is standard equipment for all PB Mud Guns. Note metal sleeve which prevents seepage of mud behind rubber lining. For most muds, RUGBY will outwear those of metal design. Chrome tungsten alloy lined nozzles, not shown, for jetting oil base and chemical muds, are also available.

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the Association and praised the various educational programs inaugurated by the AAODC, stating that they were responsible in a large measure for better organized, safer drilling activities. Contractors increase the rate of penetration while studying the methods of further progress, Whaley stated. "Contractors today are technical specialists with an expert's knowledge, equipment, organization, system, and operating practices."

Whaley also named several of the manuals published by the AAODC, and many of the improvements brought about through working with the API on standardization of drill collars, and improved techniques. In conclusion, Whaley stated that oil companies, when negotiating a contract, are "fully aware of and in sympathy with the problems that arise."

Frank Morgan, vice president of Richfield Oil Corporation, Los Angeles, California, and past president of the American Association of Petroleum Geologists, made the principal address on the significance of geology to the drilling phase of the industry.

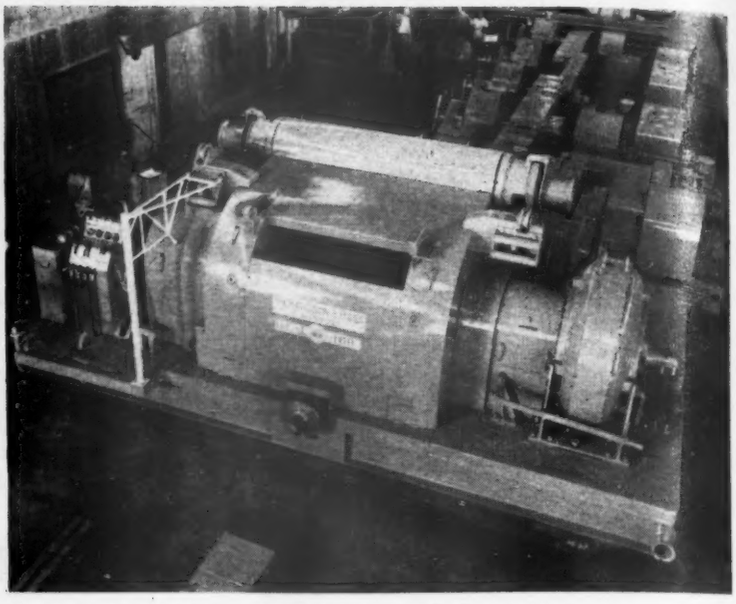
Largest directors' meeting in the Association history was held on September 28. Two full days of convention activities followed, which included technical and non-technical papers. * * *

First photo, Doug Graham, Dunlap and Graham, Long Beach; Elmer Decker, Martin Decker Company, Long Beach, California; and J. H. Hester, Republic National Gas Company, Dallas. *Second,* Otis Daniels, Kerr-McGee, Bob Femester, Ideco, Houston, and Gene Shiels, Ideco, Dallas. *Third,* Max B. Campbell, president, and Otto B. Hamer, both of Security Engineering, Whittier, California.

Left, John Grant, Loffland Brothers, Los Angeles; R. W. Wire, president, Loffland Brothers, Tulsa, Oklahoma, and Mrs. Wire; W. C. Moser, National Tube, Dallas, Texas; Mrs. Moser; Ken W. Davis and James Moon, Bender Derrick, Corona Del Mar, California. *Right,* Wally Barrersteine and Ross Brewer, Continental Supply Company, Tulsa; Noble Endicott, Continental Supply, Houston; Ken W. Davis, Mid-Continent Supply, Fort Worth, and Hugh Kelley, Hughes Tool Company, Oklahoma City.

First photo, Irle Nichols, Nichols and Duncan Drilling Company, Duncan, Oklahoma; Hank Toller, Jet Drilling Company; S. R. Clinkscales and J. C. Morrison, Mid-West Drillers, Liberal, Kansas. *Second,* Mr. and Mrs. A. H. Bell, Bell and Burden Drilling, Los Angeles, and Mr. and Mrs. Byron Landis, Web Wilson, Los Angeles, enjoy themselves at one of the many entertainments provided. *Third,* T. W. Cooper, Oklahoma City; J. P. Alexander; and C. E. Blount, Blount Drilling Company, Oklahoma City.

Closeup of 5-section drive group of power plant for rig on drilling barge. Fluid drive serves each engine. Each Gyrol unit may be filled accurately by remote control from a cabinet at the driller's position. Each unit is controlled separately, making it possible to vary the flow of power from each engine individually.



Draw works for rig on new Richardson and Bass drilling barge, shown at National Supply's Torrance, California, plant prior to installation. The drum, grooved for 1½-in. wire line, permits hoisting 135-ft drill pipe stands with 8 lines without spooling more than 3 full layers of line in the drum. Draw works includes a 60-in. hydromatic brake, and micromatic drilling control.

Barge "Blind Pass" Fitted for Deep Gulf Coast Drilling

DESIGNED to handle any known or contemplated drilling job in the Gulf Coast area, the new Richardson and Bass drilling barge, "Blind Pass,' is now on location at Blind Pass, near St. Joseph Island. The location, about four miles southeast of Rockport, Texas, is reached by boat from Aransas Pass, where loading facilities have been built.

Projected depth of the initial well is around 12,000 ft. The area is wildcat territory, however, and the well may run to 14,000 ft.

Five Engines Give 3350 hp

The rig* is first of the type rig that drilled the world's deepest well, 20,521 ft, in 1949. Power plant of the "Blind Pass" consists of five drilling engines,† supplying a total of approximately 3350 hp. This is the largest power plant on any drilling rig in the Gulf Coast area.

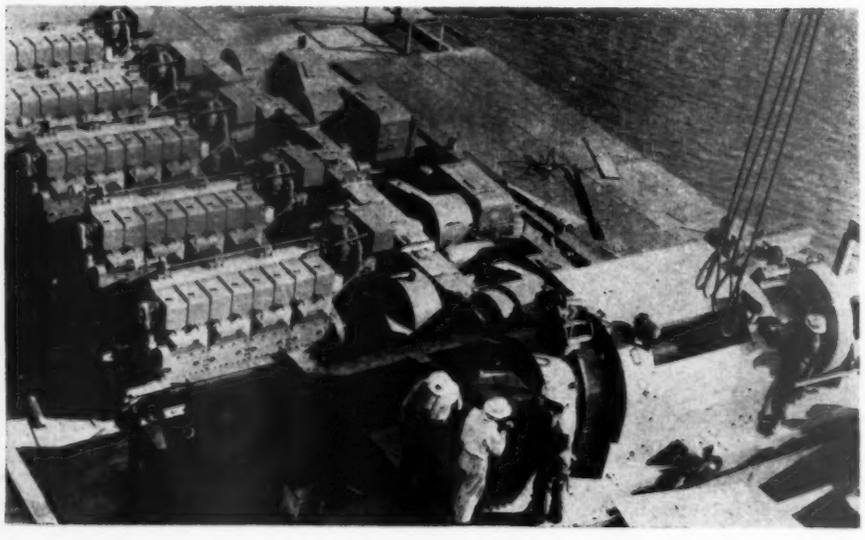
Engines are arranged side by side, with means provided for distributing the power between the draw works, the rotary and the mud pumps, including the mud mixing pump. All engines are standby for one another. Engines are mounted on rubber vibration dampers.

A new device for the control of the scoops in the Gyrols is introduced with this rig. Known as the Pneudyne,‡ it permits acurate filling of each Gyrol unit by remote control from a cabinet at the driller's position. Each unit is controlled separately, making it possible to vary the flow of power from each engine individually.

The barge was built by the Levingston Shipbuilding Company, Orange, Texas. All drilling equipment was furnished by The National Supply Company.

*National Supply's Ideal Type 160 Consolidated.

Scene during installation of power plant on drilling barge "Blind Pass." Note use of five supercharged dual fuel engines, supplying a total of approximately 3350 hp, the largest power plant on any drilling rig in the Gulf Coast area.



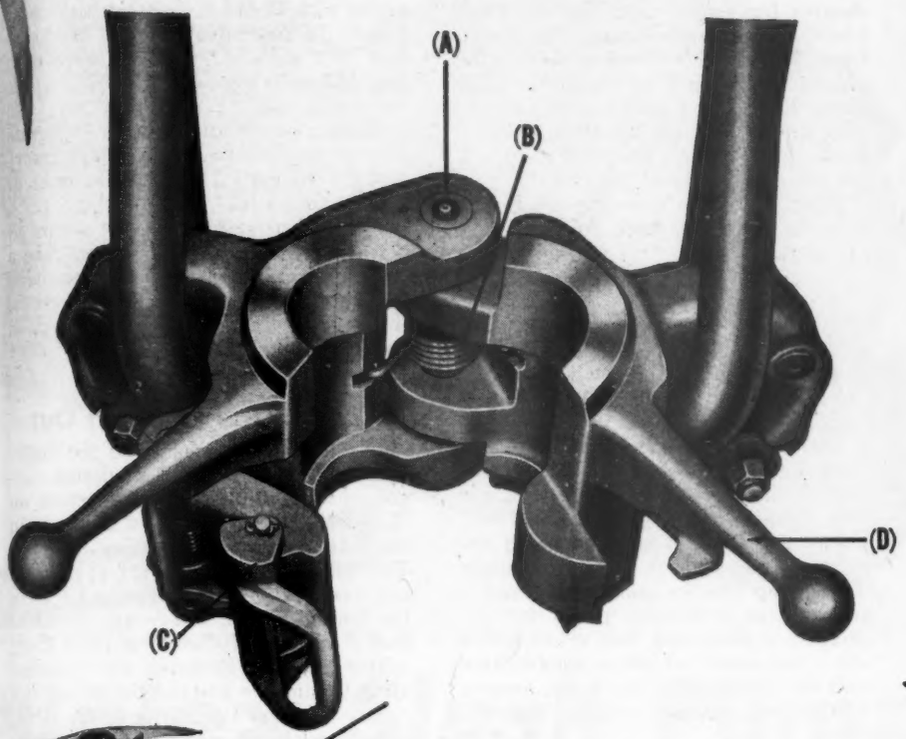
Keel Laid on April 14 and Completed August 4

Lifting capacity of the draw work and derrick tackle is suitable to the rig's unusual power plant.

Keel was laid on April 14, 1952. Completed hull was launched June 11, and installation of the major machinery was begun on June 27. Ready to drill, except for completion of the derrick, the barge left the shipyard on August 4. It was towed via the Intracoastal Canal to Rockport where the drill pipe was loaded. It was then towed to the drilling location, where the derrick was erected, the crown block set, and the lines strung. The derrick was not erected at the shipyard because of overhead obstructions between there and the drilling location.

†Superior PTDSG-8 Supercharged dual fuel.
‡Made by Westinghouse Air Brake Company.

WORLD'S BEST ELEVATOR

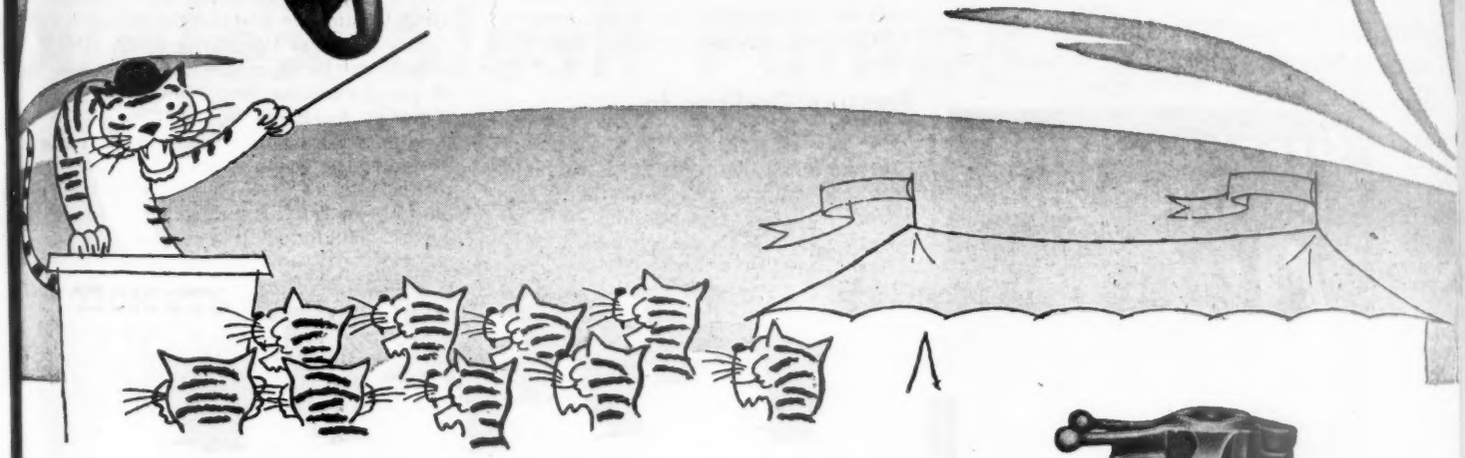


(A) This fitting (safely recessed in the hinge pin) permits proper lubrication to ensure easy opening and closing of elevator.

(B) This spring opens the elevator and forces it off and away from the pipe.

(C) The safety lock closes automatically with the latch; and one easy motion opens both lock and latch.

(D) Guards on handle protect hands from injury against the links.

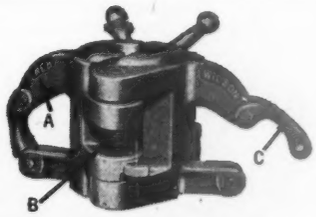


The *exclusive* features shown above are sufficient to make the Web Wilson "Balanced" Center Latch Elevator the WORLD'S BEST—and the choice of fast-moving, safety-minded crews—but there are **OTHER IMPORTANT FEATURES!** Remember that these "Balanced" elevators are made from Manganese-Molybdenum steel, properly heat treated—all pipe contacting surfaces are flame hardened to wear a long, long time—and see other advantages at right.

FOR ALL TYPES AND SIZES OF DRILL PIPE. Web Wilson "Balanced" Center Latch Elevators are available for Regular and External Upset "Collar Type" drill pipe, and also for "Bottleneck" (18-degree taper) drill pipe. Made in 12 sizes to handle drill pipe and tubing from 1¼" to 7".

YOUR supply store has Web Wilson "Balanced" Center Latch Elevators in stock—or can get one for you—pronto!

The slanted hinge pin, which provides automatic closing, is clearly seen above.



A–Rugged Link Arms fit links perfectly.
B–This spring opens the elevator and forces it off and away from the pipe.
C–Link Arms are easily operated, but are securely locked in place.

WEB WILSON Oil Tools INC. FIELD PROVEN

LOS ANGELES, CALIFORNIA • HOUSTON, TEXAS • NEW YORK, N.Y.

Drilling began eight days after leaving the shipyard.

The barge is 190 ft long, 54 ft wide, and 12 ft deep, with a slot 89 ft 6 in. long by 8 ft wide. It has an active mud capacity of 750 bbl, consisting of two active mud pits and a 120-bbl settling pit, and a reserve mud capacity of 1500 bbl. It has a fuel capacity of 1120 bbl and a fresh water capacity of 4650 bbl.

Displacement of the barge, as it left the shipyards, was 1280 tons, with draft of 5 ft displacement with all bulk heads empty.

The "Blind Pass" has quarters for eight men, as well as a galley, tool pusher's quarters, and office, all completely air-conditioned and insulated. There is a change room with individual steel lockers for the crew.

Draw Works Floor

The draw works is placed flush with the derrick floor, which is 18 ft 6 in. above the deck of the hull. Pumps and mud tanks are on the lower deck and the engines on a platform between the lower deck and the derrick floor. The pipe rack is 9 ft 6 in. below the floor.

Special attention was given to machinery arrangement to obtain the best possible trim, as this is of great importance on a drilling barge. This was done by relocating the main chain drive from the drive group and through the use of a countershaft for driving the No. 3 pump.

Wire Line

The draw works drum, grooved for 1½ in. wire line, is 36 in. in diameter and is made sufficiently long to permit hoisting 135-ft drill pipe stands with 8 lines without spooling more than three full layers of line on the drum.

Will Lift 540 Tons

The crown block has seven 60-in. sheaves for 1½-in. line. The traveling block, which complements the crown block, has six 60-in. sheaves. Each is the largest of its kind in the world. The crown block has a load capacity of 630 tons, and will safely handle suspended loads up to 540 tons. The traveling block has a load capacity of 540 tons.

Attached to the traveling block is a recently designed hook, of 450 tons capacity.

Rotary Is Shaft Driven

Other hoisting equipment includes a wire line anchor. A speed selector, which is a driller's guide to correct hoisting speeds, is installed in a weight indicator instrument panel.

The rotary machine is shaft driven from the draw works, a quiet, efficient method that is proving a boon to the crew members.

Two slush pumps serve the mud circulation requirement, while a single slush pump handles mud mixing and is available as a standby pump for circulating. Each pump has a full speed and a half speed, which, in combination with the flexibility of the drive, assures a full speed and power range for each pump.

* * *

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Pressure Declines in East Texas Oil Field

Pressure in the East Texas oil field declined slightly in September, The Texas Railroad Commission has reported. Olin Culberson, chairman, said that the East Texas test wells averaged 1015.83 psi pressure on October 1, down 0.58 of a pound for the month. The field's oil quota was cut by 21,496 in October because its energy was decreasing.

Western Geophysical Moves

Western Geophysical Company has moved its Los Angeles research department into a newly constructed building at 923 North La Brea Avenue. The new structure features, along with the requisite administrative essentials, an electronics research laboratory, shop facilities for the assembly and testing of all instruments and equipment required for geophysical prospecting, as well as for the exploitation of new ideas. Western now has 53 geophysical crews in the field, mostly in the United States and Canada.

Production Taxes Climb

Texas oil and gas production taxes have increased 750 per cent during the last 12 years, according to the Texas Mid-Continent Oil and Gas Association. The state treasury has collected some $688,000,000 from 1940 to 1951 from this source. Another $138,000,000 was collected from oil and gas producers in the 1952 fiscal year, an all-time high, the Association reported.

Michigan Reports Output Of Oil Down in 1951

Michigan has reported that oil activities decreased in the state during 1951 from 1950. Oil production dropped from 15,826,148 to 13,926,518 bbl. Gas production was 10,524,495,000 cu ft compared with 12,614,024,000 cu ft the year before. In December of 1951, Michigan had 3911 wells of which 309 were flowing: 152 wells were drilling, 35 of which were wildcats.

Exploration continued at a high rate throughout 1951. Thirty exploratory wells were drilled to the Richfield or deeper formations, and of these tests, five were discoveries. One discovered oil in the Detroit River "sour zone," one a Richfield deep producer, two extended Richfield pools, and one discovered oil in the Salina. The deepest test was in Otsego County at 6712 ft, where Salina oil was hit.

IOCC Unitization Report Out

The headquarters office of the Interstate Oil Compact Commission announces the publication of a report on "Unitized and Cooperative Projects in the United States, September 1, 1952." This publication is a survey of unitized and cooperative agreement projects in the United States, which was prepared under the supervision of a Joint Committee from the Research and Coordinating Committee and the Secondary Recovery Advisory Committee of the IOCC with Tom M. Winfiele, chief engineer of the Louisiana Department of Conservation, as chairman.

This publication contains the data reported to the Committee on 173 unitized projects in 13 states and similar data on 23 cooperative agreement projects in 7 states. Included in the report are 36 charts relative to reservoir performance or production and 10 maps showing the areas covered by individual projects.

Copies of this report may be obtained from the Interstate Oil Compact Commission, Box 3127, State Capitol, Oklahoma City 5, Oklahoma.

Gas Products Increase

Post-war construction of gas processing plants in Texas has developed a current capacity nearly triple that of 1946. These natural gas liquids are produced in Texas' 183 natural gasoline plants and its 35 cycling plants from natural gas that was once wasted, the Texas Mid-Continent Oil and Gas Association reported.

Kansas May Set New Record

Kansas is almost assured of a new drilling record in 1952. The State Corporation Commission has announced that in August completed tests numbered 379, bringing the 1952 total to 2989 completions. This was an increase of 299 from the comparable period in 1951, record year to date in Kansas.

The State Corporation has also reported 13 new oil fields listed by the nomenclature committee. This brings the 1952 total of new field discoveries to 171.

WHELAND

HP-8000 7¼" x 12"
delivers 577 GPM at 555 PSI with 7¼" liners to 322 GPM at 995 PSI with 5½" liners at 70 RPM.

220 INPUT HORSEPOWER

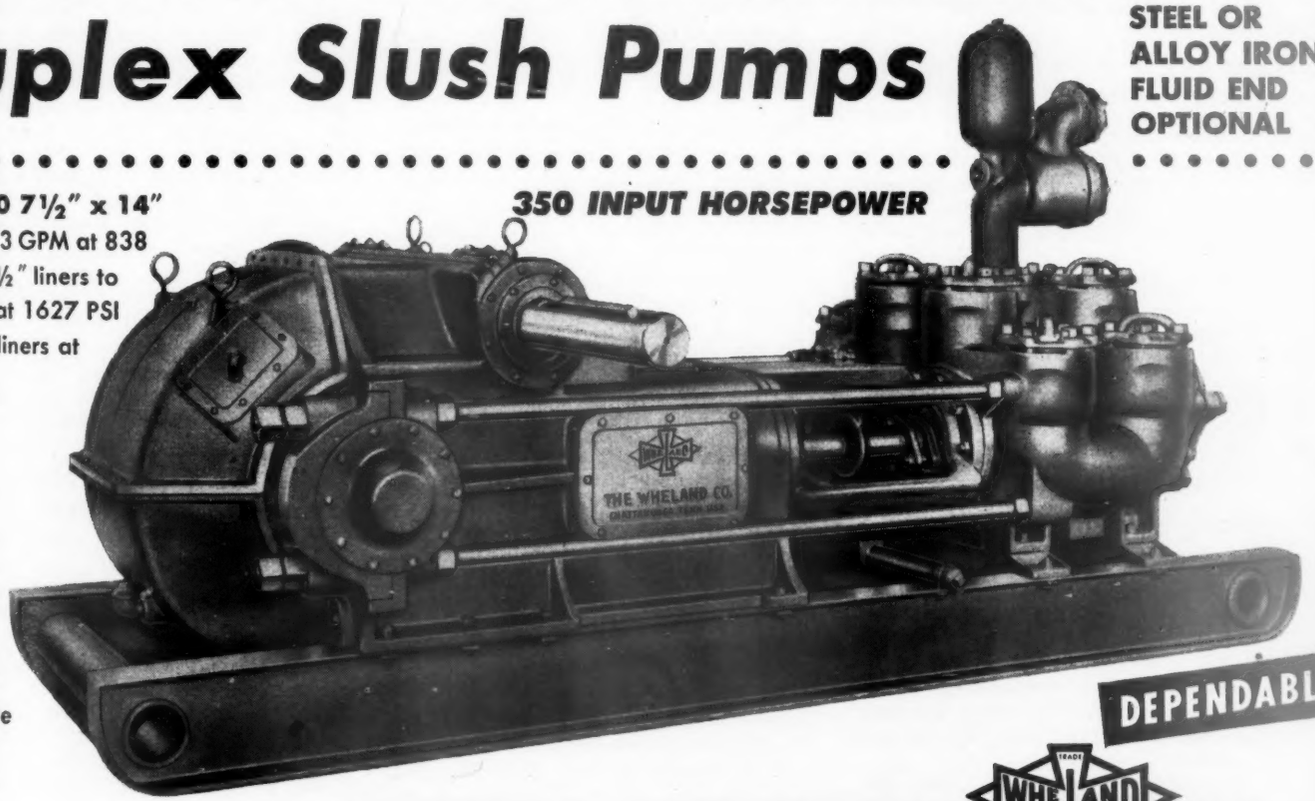
RE PRESSURE—MORE MUD

Duplex Slush Pumps

STEEL OR ALLOY IRON FLUID END OPTIONAL

P-14000 7½" x 14"
elivers 613 GPM at 838 SI with 7½" liners to 16 GPM at 1627 PSI ith 5½" liners at 0 RPM.

350 INPUT HORSEPOWER



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THE WHELAND COMPANY, CHATTANOOGA, TENN., U. S. A.
ROTARY DRILLING MACHINERY

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Survey Reveals Explosives Cause Few Accidents

Explosives cause less than one per cent of all injuries sustained by geophysical field crews, according to Curtis H. Johnson, president of the Society of Exploration Geophysicists and assistant chief geophysicist for General Petroleum Corporation, Los Angeles, California. Johnson made this statement recently in announcing formal sponsorship of the Geophysical Accident Exchange by SEG.

The Geophysical Accident Exchange is a co-operative effort by twenty-three oil companies and geophysical contractors through which accident facts are made available to the participants so they can properly plan their own accident prevention programs, Johnson said.

Each company participating in the accident exchange submits monthly reports, anonymously, to H. Pepper Jackson of Tulsa, Oklahoma, an agent who is not connected with the geophysical or oil business. Jackson combines these statements in a report that is distributed monthly to the participants on a subscription basis. The information is analyzed periodically by the SEG safety committee to point out the field operations causing the most injuries.

New Gas Discovery Hit In Republic of Ecuador

A gas discovery well has been reported in the Republic of Ecuador. It was brought in by Manabi Exploration Company, Inc., subsidiary of Canada Southern Oils, Ltd.

The new well flowed in excess of 5,000,000 cu ft of gas daily on initial tests. Called the No. 1 Filomena, the wildcat well produced from a 32-ft section of the Socorro formation, which was encountered at a depth of 1060 ft.

Cecil V. Hagen, president of Canada Southern reported that the well is about five miles southeast of the Santo Tomas field, which is at the present time producing approximately 3000 bbl a day from the Socorro formation. The new well is situated on the Santa Elena Peninsula.

Water Flooding in Indiana Discussed in IOCC Report

The Interstate Oil Compact Commission announces publication of a report "Water Flooding Operations in Indiana to 1951" prepared by the Secondary Recovery Committee for Indiana in co-operation with the Secondary Recovery Division of the Interstate Oil Compact Commission.

This report contains the data prepared by the Indiana Secondary Recovery Committee including eight water flooding operations that were active on January 1, 1951. In addition, three of the projects are described.

The report contains 12 maps, graphs, or charts showing conditions or histories in seven of these projects.

Copies of this report may be obtained from the Interstate Oil Compact Commission, Box 3127, State Capitol, Oklahoma City 5, Oklahoma.

William Anderson, C. C. Gandaubert, H. F. Dangberg, and L. C. Johnson received citations for service from Pacific Coast API.

Pacific Coast API Men Receive Service Citations

At a recent meeting of the Los Angeles Basin Chapter of the Pacific Coast District of the American Petroleum Institute, four members were honored with Citations for Service. Recipients of the awards were: C. C. Gandaubert, of the General Petroleum Corporation; H. F. Dangberg, Hancock Oil Company; William Anderson, Oil Tool Corporation, and L. C. Johnson, of Union Oil Company. Citations were presented by T. H. Acres, of Sunray Oil Corporation, Chairman of and on behalf of the Pacific Coast District of the API.

Harrison and Company Moves

Robert W. Harrison and Company, consulting petroleum engineers and geologists have announced removal of their offices to 1069 San Jacinto Building, Houston. Offices were formerly at 504 City National Bank Building. Telephone number is BLackstone 0439.

Davis Addresses AAPG

Morgan J. Davis, president of American Association of Petroleum Geologists, was one of the principal speakers at the annual meeting of the Independent Petroleum Association of America in Oklahoma City, October 23-24.

He discussed "Progress In Oil Finding" at a luncheon session on the final day of the meeting. Davis is vice president and director in charge of exploration of Humble Oil and Refining Company at Houston. He joined Humble as field geologist in 1934.

He received his first training in geology at Texas Christian University, Fort Worth, later transferring to the University of Texas at Austin.

Britco Obtains Interest In Three Canadian Wells

Britco Oils, Ltd., has acquired 100 per cent interest in three producing natural gas wells in Kent County, southwestern Ontario, Canada. The new wells are the No. 1 and No. 3. Production from these wells, since they were drilled in 1933 to the end of 1951, totals more than 265,000,000 cu ft of gas. In 1951 they produced 7,037,000 cu ft.

California Company Opens Florida District Offices

The California Company has announced opening of new district offices in Pensacola, Florida, in the DeSoto Building. The newly created district offices will be in charge of the company's operations in Alabama and Florida.

J. E. McCall, district geologist, will head the geological department of the office. Other geologists assisting McCall are: William E. (Bill) Linn, Russell Alexander, and George Bockroth. Jim Walter will be the draftsman. Scout for the new distict will be Paul Jeffus, who was transferred from the company's Jackson, Mississippi, district office. He will be replaced in Jackson by C. S. McClelland.

In charge of the company's land department is Larry Scott, district landman. Three additional land men will operate under the Pensacola office, but will continue to maintain offices in Brewton, Alabama. They include James W. Mays, and Fred T. Helms.

Increased operations by California Company in Alabama and Florida areas during the coming months is indicated by opening of the Pensacola office.

Carter Oil Sets Up New Area Office in Ardmore

The Carter Oil Company has announced the opening of a new area office at Ardmore, Oklahoma. Lee R. Riley, formerly geologist at Oklahoma City, will be in charge of the new office.

Bert W. Huls, area land man about to be released from the Marines, will be associated with Riley, William V. Snider, area geophysicist, and two scouts, T. G. Price, and B. M. Burch.

The new office will be in the Champion Building.

Test Well in Mozambique

Mozambique Gulf Oil Company is drilling its first test well in southern Mozambique, 16 miles west of Maxixe. The new company is a subsidiary of Gulf Oil Company, and has been carrying on exploratory operations in the Sul do Save area of southern Mozambique for more than 4 years.

New Aerial Shooting Method Announced by Jakosky

Dr. J. J. Jakosky, president of International Geophysics, Inc., Los Angeles, announces the development of a new aerial shooting technique involving the use of a recently perfected high intensity, explosive bomb, more powerful than any hitherto used in seismic exploration. The bomb is ejected from a mortar on the surface of the ground, the height at which it is exploded being determined by the characteristics of the area and the depth of exploration.

Geophysicists have so far almost exclusively tamped their explosive charges into shot-holes, or jetted them into the ocean bed in order to create the artificial earthquakes that are their stock-in-trade. According to Dr. Jakosky, however, the new procedure is much less expensive and in many areas is just as effective.

The equipment required for aerial shooting is light, the entire mortar assembly weighing a mere 72 lb, while a complete shot-hole drill with its accessories, even without the truck, weighs approximately six tons. This, of course, will enable the geophysicists to fly into remote foreign areas and to reach into many hitherto inaccessible spots.

Laird Predicts Oil Is on Eastern Side of Williston

Oil will someday be found on the eastern side of the Williston Basin in North Dakota, Dr. Wilson M. Laird, state geologist, predicted recently. He based his belief on the fact that oil was discovered in the eastern part in Manitoba, Canada, where geologic formations are identical to those in eastern North Dakota, and the fact that oil has come from formations of this type in other parts of the country. Laird added that as yet geologists had not agreed on just where the eastern side of the Basin is situated.

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Century Company Opens New Sales and Service Office

An office to handle Canadian sales and service of geophysical equipment has been opened in Calgary, according to Opie Dimmick, president, Century Geophysical Corporation, Tulsa, Oklahoma.

H. B. Munsey

The new office, under the direction of H. B. "Hank" Munsey, was opened at 223 Examiner Building in connection with Century's Canadian division. Munsey, until this time, has been superintendent of production and coordinator of customer service at Century's Tulsa plant. He was previously with Bell Telephone Company for 20 yr as installation supervisor.

Earlier this year Century Geophysical Corporation of Canada, a wholly-owned subsidiary, was organized in Calgary. James K. Ziegler is vice president in charge of the Canadian corporation.

Petroleum Engineering Acquires Lith-O-Log

Lith-O-Log, Inc., cutting analysis service has been acquired by Petroleum Engineering Associates, Inc., Pasadena, California. The company will be known as the field division of Petroleum Engineering Associates, according to Florent H. Bailly, president. In addition to the cutting analysis service, Lith-O-Log has developed a porosity-permeability-saturation (PKS) unit for core evalution and salinities at the rig site. "Presently, operations are confined to California, but proposed plans call for expansion into other oil producing areas," Bailly stated.

Sinclair Somal Acquires Concessions in Italy

Sinclair Somal Corporation, a subsidiary of Sinclair Oil Corporation, announces that Amerada Petroleum Corporation, Continental Oil Company, and The Ohio Oil Company have each acquired a one sixth interest in the petroleum concession held by Sinclair Somal Corporation in Italian Somaliland. Geological operations have already begun.

L. V. Stanford, president of Sinclair Somal Corporation, stated that the company has opened an office in Mogadiscio under the direction of T. J. Donovan, assistant to the president.

Aramco Oil Output Up

Crude oil production in Saudi Arabia during September amounted to 24,558,414 bbl, or an average of 818,614 bbl per calendar day, it was announced by the Arabian American Oil Company. This compared with 25,316,284 bbl produced in August, an average of 816,654 bbl per day. Production for the first nine months of 1952 was 232,506,621 bbl, an average of 848,564 bbl per calendar day.

Carter Holds Reservoir Engineering School

Representatives of affiliates of Standard Oil Company (New Jersey) in Sumatra, Saudi Arabia, Peru and other countries as well as personnel from subsidiaries in the United States in Tulsa, Oklahoma attended a six weeks reservoir engineering school, recently conducted by The Carter Oil Company research department.

New methods of determining reservoir behavior, analyses of production mechanisms, evaluation of gas reserves, and waterflooding principles are some of the subjects studied by 31 oil men from Jersey companies worldwide, H. F. Moses, Tulsa, Carter vice president in charge of exploration and research, said.

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Permian Basin Oil Show Success

Some 250 oil field exhibits were displayed at the Permian Basin oil show held in Odessa, Texas, October 16 through 19.

An API pre-show Pow Wow was held on October 15. An Oil Show Parade was held on the opening day and in the evening there was a Wildcatters banquet with Fulton Lewis as the guest speaker.

The local chapters of the Desk and Derrick, AAODC and West Texas Geological Society had a joint social meeting on the evening of October 17. The Odessa Chuck Wagon Gang gave a barbecue on the Saturday afternoon.

Officers of the Oil Show were: president, L. R. French, French Tool and Supply Company; first vice president, Early Spiars, Spiars Equipment Company; second vice president, W. D. Land, Plymouth Oil Company; treasurer, Roy E. Carter, Carter Foundation Production Company; general manager, Carlos Clover, public accountant.

IPAA Committee Fears Steel Shortage

An oil well drilling program scheduled by defense agencies faces failure if production of oil country tubular goods is not hiked by at least 12 per cent in 1953, according to the Independent Petroleum Association of America. Pipe shortages have already defeated defense requirements for 25,000 wells in the last half of 1952. And a committee of the IPAA holds out no hope for improvement next year when the industry will be expected to drill 55,000 wells.

Admitting a lack of information on U. S. mill capacity and future steel supplies, the Oil and Gas Field Materials Committee of IPAA today said latest statistics available (1951) show mill output at 1,900,000 tons of pipe annually. Using this production as a basis, the committee forecast a shortage of 300,000 tons, or 12 per cent of requirements in oil country casing, tubing, and drill pipe next year "provided pipe exports do not increase."

"A 12 per cent deficiency in steel supplies, if translated into wells drilled would mean a failure to accomplish the 55,000 well program by more than 6000 wells," it reported.

Secondary Recovery Methods Described

Air-gas injection and other modern techniques used on an oil producing property near Oil City are expected to recover 80,000 bbl of oil that conventional methods would leave in the ground, oil men were told in State College, Pennsylvania, recently. The report, one of a dozen scheduled on experimental projects in petroleum production, was prepared by Bruce F. Grant and Robert L. Rougn of the Franklin station, U. S. Bureau of Mines, and Robert B. Bossler of Brundred Oil Corporation, Oil City, for the 16th annual technical conference on petroleum production at Pennsylvania State College.

Air-gas injection helps restore reservoir pressure in the oil formation, enabling old wells to produce oil by flowing instead of pumping. The authors pointed out that, although flowing requires more closely controlled operations than pumping, the practice has proved profitable. One reason given is that flowing wells do not have to have tubing and rods pulled out as frequently as do pumping wells for paraffin removal and replacement of valve parts, thus cutting operating expenses.

SACROC Unitization Project Endorsed

Sufficient signatures representing royalty and working interest ownerships in the Kelly-Snyder and Diamond "M" fields of Scurry County, Texas, have been obtained to qualify the SACROC unitization project, it has been announced by the land committee of the Scurry Area Canyon Reef Operators Committee. The SACROC unit includes 1227 producing wells on more than 47,000 acres comprising the Kelly-Snyder field and part of the Diamond "M" field.

R. F. Bryant, Jr., Magnolia Petroleum Company, Dallas, chairman of the SACROC land committee has notified M. Darwin Kirk, Sunray Oil Corporation, Tulsa, chairman of the SACROC executive committee that more than 93 per cent of the working interests and approximately 80 per cent of the royalty interests have signed the unitization documents. The project is the world's largest oil conservation plan to gain an additional three-quarters million barrels of oil production through regulated pressure maintenance.

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ENGLAND

What's Doing in Drilling

Stanolind Well Completed In Alabama's Pollard Field

Stanolind Oil and Gas Company has a new oil well in the extreme southern part of Alabama in Pollard field. It is the St. Regis Paper Company A No. 2 well in Escambia County, which topped the Marine sand at 5862 ft. The No. 2 well is drilling ahead in saturated sand at 5900 ft toward a projected depth of 6500 ft. This is on a part of Stanolind's extensive acreage holdings northwest of and on trend with the Pollard field. Perforated 5870-73 ft opposite the Pilot sand, the well flowed at the rate of 189 bbl of 29.3 gravity oil per day through ⅛-in. choke. Tubing pressure was 175 lb and casing pressure 350 lb. Although the St. Regis Paper Company No. 1 well was not completed as a commerical producer, it indicated the Pollard discovery.

Pollard Field Gets New Well.

Humble Oil and Refining Company has completed a new well in Pollard field, Escambia County, Alabama. It is the company's No. 2 Mrs. Lillie Congleton et al. On completion test, the new well flowed 99.36 bbl of oil per day through ⅛-in. choke. Tubing pressure was 200 lb, casing pressure 180 lb and gravity of oil 28.4 deg API. Production is from casing perforations opposite the Pilot sand at 5948-52 ft.

Conoco Well Added to Colorado Oil Field

Continental Oil Company completed its Pollack "A" No. 6 exploration test well in the North McCallum field, Jackson County, Colorado. The well was completed for an initial potential of 224 bbl of oil and 10,863,000 cu ft of carbon dioxide gas daily. Gravity of the oil was 47.6 deg. The well was completed at a total depth of 5740 ft in sand after being plugged back from 6170 ft, with 5½-in. casing set at 5630 ft.

Montana Well Success

The Texas Company has a second well in the Northwest Sumatra area, in an apparently new pool in Rosebud County, Montana. The well is the No. 2 Grebe, which was given an initial potential of 224 bbl of 35.5 gravity oil daily. It flowed from perforations between 4723-63 ft and 4800-40 ft. First well in this field had a flow rate of 283 bbl per day from the 4719-32 ft zone.

Shell Well Flows 524 Bbl

Shell Oil Company has a new well in the Elk City field of Beckham County, Oklahoma. It is the No. 3 Rumberger, which flowed 524 bbl of oil in 14 hr, gravity 37.5, with a gas-oil ratio of 3890-1, before operator pulled tester. The test was made on perforations 9923-86 ft, and had oil and gas to surface in 20 min. Plugged back depth is 9997 ft.

Two New Zones Tested In New Mexico Field

Two new horizons may prove productive in the Mescalero Wolfcamp field in Northwest Lea County, New Mexico. Well is Cities Production Company's No. 1 AD State, which tested the Devonian at 9835-60 ft. On this test oil reached the surface in 40 min, and in 4 hr it flowed 329 bbl of oil for a gas ratio of 21 to 1. The new well also topped the Mississippian at 9532 ft and was tested for three hours at 9765-812 for recovery of 1160 ft of oil, 210 ft of oil and gas cut mud, and 330 ft of sulfur water. Before tests the well showed production possibilities in two higher sections.

Sandstone Production Hit

Cities Service Oil Company (Delaware) is providing the Southwest Maysville pool of Garvin County, Oklahoma, a quarter-mile extension of Oil Creek sandstone production. The extension was confirmed in the company's Reis No. 1, when the well flowed 341 bbl of oil in 20 hr and 20 min from perforations in the Oil Creek between 8290 and 8310 ft. Producing formation was topped at 8284 ft.

Pure Completes Fourth Multi Zone Gas Well

Pure Oil Company has completed its fourth multi-zone gas well in the Eugene Island field 10 miles off St. Mary's Parish, Louisiana, in the Gulf of Mexico. The new well was drilled to 11,703 ft, and was given an open flow potential of 70,000,000 cu ft a day. The well encountered the gas-producing horizons present in the three previously drilled wells.

Shallow Discovery Made In Louisiana County

California Company has a new and shallow oil sand discovery in the West Delta pool in Lafourche Parish, Louisiana. It is the No. 1 W. A. Jones Unit 1, which was originally completed as a gas-condensate producer from 11,269-275 ft, and is now completed from perforations at 9461-74 ft to flow 171 bbl of oil daily through ⅛-in. choke. Gas oil ratio was 632 to 1.

Carter County Oil Well Opens New Producing Zone

Beach and Talbot has completed a zone discovery well in the Caddo pool of Carter County, Oklahoma, adding the Hunton lime as a producing formation. New well is the No. 1 Noble, which was drilled to 4605 ft with 7-in. casing set at 4604 ft. The Hunton was perforated at 4549-69 ft and showed 8 bbl of oil per hour natural on swab and flow test. The new well was treated with 1000 gal of acid, and completed flowing 33 bbl of oil per hour.

Mississippi Field Well

Ohio Oil Company has indications of a gas-condensate well in the Maxie field of Forrest County, Mississippi. It is the company's No. 1 Coleman-Powe Acct. 2, which on latest test flowed at the rate of 119 bbl of fluid containing 2.94 per cent salt water and 5,650,000 cu ft of gas per day through 1-in. choke. Tubing pressure was 575 lb, and casing pressure 880 lb. Production is from casing perforations 7382-87 ft.

Wolfcamp Zone Opened In Scurry County Field

Humble Oil and Refining Company has reported a new well in the Diamond M field of Scurry County, Texas. It is the company's No. 1-B J. E. Sorrels, a new Wolfcamp formation discovery. On an 18½-hr production test the well flowed 361 bbl of 42.3 gravity oil with 3 per cent basic sediment and water content. Flow averaged 18 bbl an hour from perforations between 5310 and 5335 ft.

Grant County Pool Extended

The East Pond Creek Pool has been extended north by L. J. Horwitz's No. 1 Bowling, in Grant County, Oklahoma. The new Wilcox sand oil well was drilled to 5942 ft, and casing set at 5932 ft. Plug was drilled in for a flow of 100 bbl of oil per hour for six hours from production in open hole. Previously the well had indicated a producer in the Mississippi with drillstem test run at 5204-73 ft to show gas in 11 min at an estimated 1,000,000 cu ft daily and recovered 180 ft of oil and gas-cut mud, 90 ft of oil-cut mud, and 80 ft of mud.

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Weeks	Total	Gulf Coast	Pacific Coast	Illinois Oklahoma Kansas	Rocky Mountain Canada	West Texas New Mexico	Arkansas Louisiana Texas	North Texas
(September)								
Fourth	2635	515	160	649	438	475	138	260
Fifth	2614	518	161	642	443	460	132	258
(October)								
First	2654	534	166	620	453	461	140	280
Second	2667	554	167	620	430	475	144	277

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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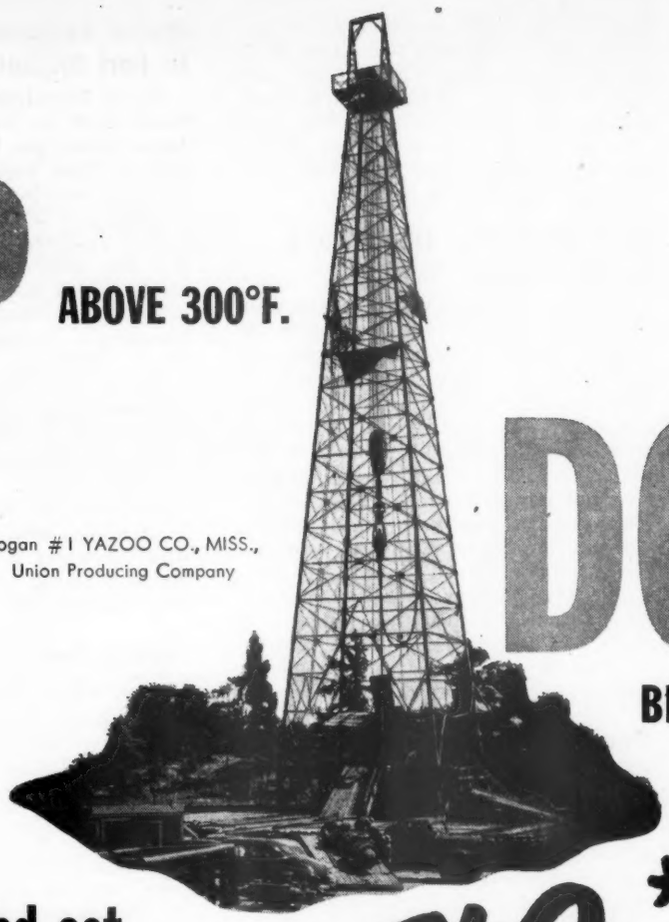

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Phillips Adds New Well To Hog Bayou Pool

Phillips Petroleum Company has completed a new well in the Hog Bayou field of southern Cameron Parish, Louisiana. It is the company's No. 1 State Lease 1170, drilled directionally from location on the shore but completed from sands beneath the Gulf of Mexico. On completion tests, the well flowed at the rate of 1,500,000 cu ft of gas and 10.4 bbl of condensate per million. Choke was opened to 16/64-in. and flow was at rate of 4,050,000 cu ft of gas and 10.6 bbl of condensate per million.

Gravity of condensate is 50.8 deg. Production is from casing perforations 8437-70 ft. Total depth was 8577 ft.

Cities Service Adds Well To Oklahoma Oil Pool

Cities Service Oil Company, et al have extended the West Pauls Valley Bromide pool of Garvin County, Oklahoma, one location northeast, indicating favorable possibilities for several additional locations. The well is Buttram No. 4. After drilling to a depth of 5601 ft, where salt water was found in the Oil Creek sandstone, the well was plugged back to test 55 ft of pay in the second Bromide sandstone from 4637 to 4692 ft. The well flowed 107 bbl of oil in 11 hours through casing perforations between 4675 and 4685 ft. It is being completed at this level.

Powell Well Opens New Productive Area

A new producing zone has been opened in the Madill pool of Marshall County, Oklahoma. L. W. Powell has completed his No. 2 Godfrey-Welch, an outpost south of Madill pool production. The well ran a 90-min drillstem test at 1529-55 ft in the Springer, surfacing gas in 70 min, and recovered 235 ft of 40 gravity oil. Total depth was 1555 ft. Regular production in Madill pool is from the Bromide.

New Gas Bearing Sand Hit In British Columbia Test

Pacific Petroleums, Ltd., and Gas Exploration Company of Alberta, Ltd., have reported that the Pacific-Gas Exploration Ryecroft No. 2 well in the Peace River area of northeastern British Columbia found a second gas bearing sand in the Gething formation. The well got its first Gething gas on test of 3737 to 3760 ft. This gave gas at 5,600,000 cu ft daily. Latest test at 3778 to 3792 ft gave gas at over 3,800,000 ft daily.

Dual-Producer Completed

A dual well has been completed in the Charenton field, St. Mary Parish, Louisiana, by Fifteen Oil Company. The well penetrated 11 producing horizons from 7100 to 10,500 ft for a total of 500 ft of net oil and gas sands. The well, South Coast No. 19, was completed with 7-in. casing set to 10,548 ft. On official state potential tests, the tubing side produced 258 bbl of pipe line oil in 24 hr on a 9/64-in. choke. Tubing pressure was 1550 lb. Gas-oil ratio was 651-to-1. Casing side produced 220 bbl of pipe line oil in 24 hr on a 9/64-in. choke, with the casing pressure 1250 lb. Gas-oil ratio was 472-to-1.

Gulf Well Hits Deep Zone In Mississippi Field

A new and deeper producing zone has been assured for the Baxterville field in Lamar County, Mississippi, at Gulf Refining Company's No. A-2 W. J. Howard. Perforated 10,864-78 ft opposite sand of Lower Cretaceous, the well flowed at rate of 5,700,000 cu ft of gas and 80.16 bbl of 51.5 gravity condensate per day through 24/64-in. choke. Flow was based on a 4- hr test. Tubing pressure flowing was 2953 lb, with gas-condensate ratio at 72,000 to one. Earlier the company made 2-hr test with the well flowing at the rate of 3,800,000 cu ft of gas and 94 bbl of 49-gravity oil per day through 13/64-in. choke with tubing pressure 3600 lb.

Deep Oil Reservoir Is Seen in Mississippi Field

A new well has opened a new pay zone in the West Lincoln field of Lincoln County, Mississippi. It is Roeser and Pendleton's No. A-5 Board of Supervisors, which flowed at the rate of 152 bbl of 40.5 gravity oil per day through 1/8-in. choke, from the new and deeper oil reservoir for the West Lincoln field. Completion was from casing perforations at 10,603-11 ft. Flow was cut with 0.6 per cent basic sediment and water. Tubing pressure was 1110 lb and gas-oil ratio 975 to one.

Humble Adds Pool Well

A new well has been added to the recently opened Lucy field in St. Charles Parish, Louisiana. It is Humble Oil and Refining Company's No. 1-B Joseph Rathborne Land Company which is shut in after flowing gas-condensate without a gage from 10,185-206 ft.

Sinclair Extends Field

Sinclair Oil Corporation has added a new well to the Wilshire (Ellenburger) field of Upton County, West Texas. Extension well is the No. 13 McElroy, which was given a flowing potential of 1746 bbl of oil. Gravity is 53.6 deg. Production is from perforations between 12,337-397 ft. Top of the producing zone was picked up at 12,337 ft.

Two California Fields

Union Oil of California has completed its Oakridge 5-10 well in the Oakridge Area field, Ventura County, California. The new well is pumping 52 bbl in 15 hr of 20.4-deg gravity crude, at 3250 ft.

In the Sansinena field, Union's No. 72 had an initial daily production of 285 bbl, net of 18.4-deg gravity crude plus 66 bbl a day of circulating oil. Present production is 365 bbl of 18.1 gravity crude through a 48/64-in. bean.

Major Extension Made In Fort St. John Field

Pacific Petroleum has announced that Pacific-Fort St. John Number 12 well has obtained gas flows totalling 3,120,000 cu ft per day, in three consecutive drillstem tests in the Upper Triassic formation.

This represents a major field extension and adds large additional gas reserves to this major field, which will be available to Westcoast Transmission Company's proposed pipe line to the Pacific Northwest.

Pacific Fort St. John No. 12 is five miles east-southeast of Pacific Fort St. John No. 9, the closest productive well, and 4½ miles due south of Pacific Fort St. John No. 10.

By these drillstem tests, a total of 34 ft of pay zone has been opened up which is water free. The well is reaming and coring preparatory to further tests and drilling.

Texaco Gets Two Big Wells In Cowley County, Kansas

Two large producers have been discovered in the Gibson field of Cowley County, Kansas. They are The Texas Company's No. 8 Bryant and No. 3 Bryant. The No. 8 was completed for 2358 bbl of oil from the Bartlesville sand, and bottomed at 3605 ft. The No. 3 was rated at 2063 bbl daily from the Bartlesville sand at 3420 ft, total depth.

Shell Well Flows From Dolomite Zone, New Mexico

Shell Oil Company has a new well in the Lovington Abo field, of Lea County, New Mexico, its No. 1-CA State. The well is being tested at 11,270 ft in Dolomite. A 2-hr test at 11,170-95 ft returned in the stem 90 ft of oil and 210 ft of mud cut heavily with oil and gas. A discovery already has been assured from the higher Permo-Pennsylvanian section.

D3 Well Productive

Standard Oil of California and Texaco Exploration Company have indicated a successful D3 formation well midway between the Bonnie Glen field and Texaco's Pigeon Lake discovery well, Alberta, Canada. The latter is three miles southeast of Bonnie Glen. This new well adds further confirmation to the Pigeon Lake discovery, which found 570 ft of oil zone and extended the Bonnie Glen field.

Conoco Producer Brought In

A good producer has been completed in the Elkhorn pool in Crockett County, Texas, where Continental Oil Company has completed its No. 1 Shannon D. The well flowed 389 bbl of 40.1 gravity oil and no water through 42/64-in. choke in 6 hr from perforations at 7224-49 ft and 7263-7324 ft in Ellenburger. Total depth is 7378 ft. Potential was based on test at the rate of 1558 bbl of oil and 7,800,000 gas, and gas-oil ratio of 501.1. Tubing pressure was 200 lb.

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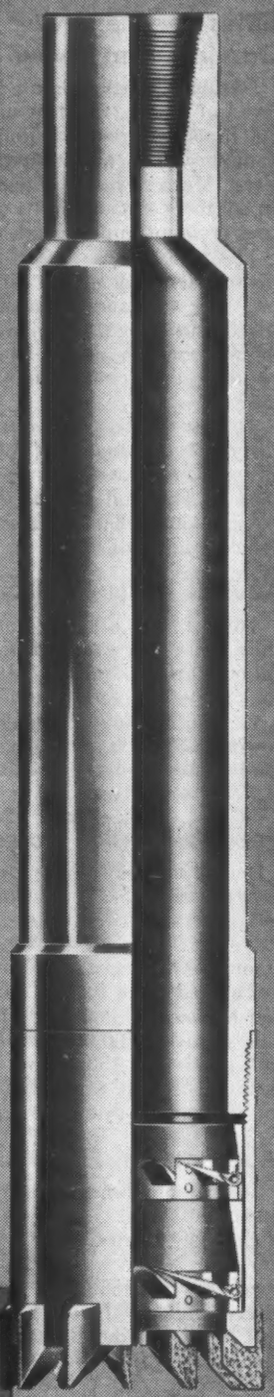

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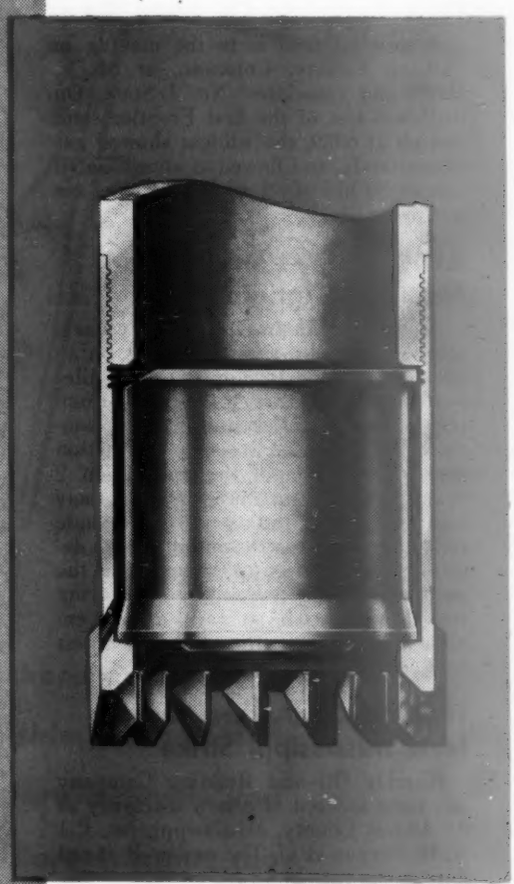

MAGNETIC TYPE CATCHER
(Patent Applied For)
. . . by simply replacing the catchers with a powerful, efficient, magnet.

Exploration Activities

New Gas Discovery Made In Peace River Area

Hudson's Bay — Union Oil — Pacific Petroleums and Canadian Atlantic Oil has announced the newest discovery well: H. B.-Union-Pacific Dunvegan No. 3, on the Alberta side of the Peace River area.

Three successive drillstem tests in the Cadotte formation (depth—1425-1465) flowed gas totaling 3,779,000 cu ft per day. As the third of the tests recovered a small amount of water it appears that a 30-ft water-free pay zone has been opened up.

The same well next tested the Notikewin formation (depth—1702-1737) and test flowed gas to the surface at the rate of 280,000 cu ft per day.

New Colorado Oil Field Seen

A new oil field is in the making in Jackson County, Colorado, at M. E. Davis and associates' No. 1 State. On drillstem test of the first Frontier sand section at 6889, the wildcat showed gas immediately, and flowed at an estimated rate of 30 bbl of oil an hour. Crews are setting casing.

AIOC Survey Party at Work Near Nottinghamshire

An Anglo-Iranian Oil Company has a seismic exploration party at work on an area around Screveton, seven miles south of the D'Arcy Exploration Company's fields at Eakrong, Nottinghamshire, England. A seismic refraction survey was made of the area about 2 years ago, and an anticline, that may contain oil, was indicated. The seismic reflection method will aid oil men to determine culmination of the anticline, the point where the potentially oil-bearing rock is nearest the surface, and so enable a possible drilling-site for a test well to be determined.

Humble Oil Assured of New Mississippi Strike

Humble Oil and Refining Company has been assured of a new discovery in its Adams County, Mississippi, No. C-1 N. H. Breaux et al. The new well gaged flow at the rate of 75 bbl of oil per day through ¼-in. choke on drillstem test. Tubing is being run in preparation for completion. Hole has been drilled to 7300 ft.

Louisiana Gets New Well

Circle Drilling Company and C. B. Pennington has opened new production in West Baton Rouge Parish, Louisiana, at their No. 1 Catherine Sugar Corporation. The new well was completed to flow 322 bbl of oil daily through a 12/64-in. choke from 9313-330 ft. Tubing pressure was 1520 lb.

Cities Service Gives Garvin County New Well

Garvin County, Oklahoma, was assured of another wildcat discovery with the announcement by Cities Service Oil Company (Delaware) that the joint-interest McCurley No. 1 test had flowed oil at the estimated rate of 15 bbl an hour from an upper Simpson sandstone.

The well flowed gas in four minutes on drillstem test at the rate of 400,000 cu ft per day, and began flowing heavy oil 55 min after the tool was opened at an estimated 15-bbl-per-hr rate through ½ and ⅝-in. chokes between 5164 to 5239 ft.

At last report, operators were preparing to drillstem test another upper Simpson sandstone between 5261 to 5268 ft. The well will be drilled to approximately 7000 ft, testing all the Bromide and Oil Creek sandstones.

Austral Drills Pool Opener

Austral Oil and Exploration Company has a new gas field opener in Vermilion Parish, Louisiana. It is the company's No. 1 Vincent and Welch, which is running tubing for completion after flowing 1,314,000 cu ft of gas plus some condensate through an ⅛-in. choke from 11,797-804 ft. Total depth is 13,803 ft.

Deep Oil Strike Indicated

Indications of a deep oil strike have been found by Shell Oil Company at its and others No. 1 Adams Community near the Dill townsite in Washita County, Oklahoma. Oil-bearing sand was picked up in the Des Moines formation between 11,068 and 11,100 ft. The well flowed 3,700,000 ft of gas a day and recovered 150 ft of 48.4 gravity clean oil, 250 ft of oil-cut fresh water, and 90 ft of gassy oil-cut mud.

Montana Oil Field Seen

Central Montana has a new oil field opened at the G. J. Greer's No. 2 Kendrick in Big Horn County, Montana. The new well, which was tested in the Tensleep between 4556 and 4588 ft for recovery of heavy black 20-gravity oil is west of the Powder River Basin. Shut-in pressure was 1800 lb.

Carter Discovery Well Made in Louisiana

A gas-distillate discovery well has been brought in in Bossier Parish, Louisiana, by Carter Oil Company at its No. 1 Crystal Oil and Refining Corporation. On an official potential test, the well flowed 238 bbl of 54.6 gravity distillate and 2,256,000 cu ft of gas daily, through a 12/64-in. choke. The well was completed from casing perforations of a sand in the Cotton Valley series at 9706-9720 ft. Tubing pressure was 4000 lb and gas-oil ratio 9482-1.

World's Deepest Cable-Tool Drilling Below 10,666 Ft

The deepest cable-tool gas well in the world is said to be New York State Natural Gas Corporation's well in Chemung County, New York. The drill had passed 10,666 ft at latest reports, and indications are it will continue to 11,000 ft or more. Record holder previously was Manufacturers Light and Heat Company in the Summit gas field, in Fayette County, Pennsylvania, which was drilled to 10,312 ft. New York State Natural's well is a wildcat in a new area, and may never prove to be a producer, but offers valuable geological informations.

Kansas Well Flows 2583 Bbl Per Day

The Kansas State Conservation Division has announced that state's 166th oil discovery of the year is a 2583-bbl a day well in Stafford County. It is Helmerich and Payne's No. 1 Koelsch, which opens the Koelsch Lansing-Kansas City field. The well was plugged back to 3820 ft, and is producing through perforations at 3750-58 ft.

Kansas Wildcat Shows Oil

Oil has been found in a new wildcat in Finney County, Kansas, by Co-operative Refinery Association northeast of the north end of the Hugoton gas field. It is the company's No. 1 Sandereggers, which cored at 4726-51 ft to show 14 ft of lime, 1 ft of shale, and 10 ft of sandy lime. On a 1-hr drillstem test, tool was pulled to find 1150 ft of gas in the pipe, plus 200 ft of free oil and 200 ft of heavily oil and gas-cut mud. Flowing pressure was 215 lb, in 15 min.

Humble Opens Production In Waller County, Texas

Humble Oil and Refining Company has opened oil production on the east flank of the old San Felipe Dome, Waller County, Texas. It is the company's No. 1 P. H. Donigan, which flowed at the rate of 180 bbl of 37.6 gravity oil daily through a 3/16-in. choke, on a one-hour test through perforations from 4572 to 4580 ft. Tubing pressure was 375 lb, and casing pressure was 375 lb. Gas-oil ratio was 270 to 1.

New Reef Strike Made

A new Pennsylvania reef field has been opened in Terry County, Texas. It is the Fullerton Oil Company's No. 1 Zorns, which is getting set for completion. The test was made at 10,007-32 total depth with gas reaching the surface in 4 min, followed by oil in 22 min. Reef was topped at 9978 ft and first showed for a discovery on a test at 9975-10,007 ft in getting oil recovery.

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Exploration

Deep Producer Indicated in Northwest Williston Basin

Stanolind Oil and Gas Company has indications of a producer in the Williston Basin at its No. 1 Waswick. The wildcat is situated in Ward County, North Dakota, some 15 miles southwest of Minot. Stanolind recovered a core with oil shows in a 2½-ft section between 10,157 and 10,177 ft. The recovery followed the water cushion and 120 ft of drilling mud. Flowing pressure was zero, shut-in pressure was 4100 lb, and hydrostatic pressure was 5400 lb. This is one of the deepest wildcats in the northwest part of the basin.

Utah Gets New Oil Pool

Carter Oil Company has announced that its newest discovery well in Duchesne County, Utah, has opened a new oil pool in that state. It is the company's No. 1 Joseph Smith, a wildcat in the Flat Mesa area. On drillsteam test at 8807 ft, there was recovery of 3080 ft of 47 gravity oil with a blow of gas. Contract calls for drilling to 9500 ft so the hole is being deepened.

Big Gas Show Seen in Utah

A good show of gas has been found at Carter Oil Company's No. 1 Johnson wildcat north of the Red Wash field in Uintah County, Utah. The well showed 5,600,000 cu ft of gas a day, at 5264 to 5304 ft, and on second drillstem test at 5335-63 ft there was recovery of 100 ft of gassey-oil-cut mud, 90 ft of oil and mud-cut water, and 910 ft of gas-cut water. Crews are drilling below 5375 ft.

Humble Oil Gives Texas New Gas-Condensate Field

A new gas-condensate field in Freestone County, East Texas, has been opened by Humble Oil and Refining Company. It is the No. 1 Fred Marberry, which flowed 5,000,000 cu ft of gas, with 1.24 bbl of condensate per 1,000,000 ft, through chokes. Casing was perforated in the Rodessa at 6544-60 ft. Total depth was 13,595 ft.

Gaspe Peninsula Surveyed

Drilling program of New Peninsular Oil, Ltd., to explore the petroleum possibilities of the Gaspe Peninsula on Canada's east coast, is underway. Erection of the derrick and installation of the company-owned drilling rig by Circle Drilling Company, Louisiana, has been completed.

First phase of the program is to deepen the well of a predecessor company. It is now being cemented at 5000 ft where it began to curve to the north. Casing from surface to that depth has been installed. The purpose is to intersect a Silurian coral reef known to be petroliferous and occurring at this location at a depth of 6000-7000 ft.

New Utah Wildcat Staked

Cities Service Oil Company has another rank wildcat in Utah. The new test is Firewater Canyon No. 1, in Uintah County. The new location is 13 miles southeast of the company's Peters Point No. 1 wildcat in Carbon County, which already has a good gas show. The Uintah County test is 50 miles southwest of the Red Wash and 40 miles southeast of the Duschesne pools and approximately 60 miles southwest of Vernal. Expected total depth of the wildcat is 8000 ft and the principal objectives are the Green River, Wasatch, and Mesa Verde sandstones.

Tide Water Completes Well In Saskatchewan, Canada

Tide Water Associated Oil Company, as operator for itself and Atlantic Refining Company, Ohio Oil Company, and Columbia Carbon Company, announces the completion of a discovery well in the Saskatchewan portion of the Williston Basin.

The well, known as the Eastend Crown No. 1, drilled to a total depth of 7458 ft and plugged back and 7-in. casing run and perforated opposite the Jurassic lime interval 4740 to 4818 ft.

Although lack of sufficient storage has prevented an extended production test, the well was swabbed and flowed at a rate of approximately 800 bbl per day without lowering the fluid level below 300 ft.

South Dakota Test Staked

Work is underway on a rank wildcat in Haakon County, South Dakota, where a new test well is being drilled by Carter Oil Company. Test is the No. 1 Haakon County, and is being made based on indications that the potential highs in the Williston Basin include a dip into South Dakota that resembles a "V".

Amerada Discovery Flows At Rate of 204 in 2½ Hr

Amerada Petroleum Corporation and others have a flowing discovery in the Mississippian formation in Yoakum County, West Texas. The discovery flowed 204.62 bbl of 41.9 gravity oil, no water, in 2½ hr on a 4-hr drillstem test between 11,020-11,095 ft. Gas oil ratio was 1397 to 1. Mississippian was topped at 10,960 ft.

Arkansas Field Opened

McAlester Fuel Company and associates have reported completion of their No. 1-A Williams in the Meriwether area of Lafayette County, Arkansas. The new well was drilled to 4020 ft, and plugged back to 2435 ft. It tested 11 bbl of oil from the Tarkio Sand, and oil tested 15.7 gravity from perforations at 2364-2373 ft.

Colorado Gas Field Opened

Southern Production Company may have a new gas field in Washington County, Colorado, at its No. 1 Mott. The well is situated 6 miles northwest of Akron, in the Denver-Julesburg Basin area. After topping the "J" sand, at 4842 ft, drillstem test at 4843-58 revealed an estimated 5,000,000 ft of wet gas a day.

Clearfork Discovery Made

Woodward and Company and Dan Auld have a Clearfork zone discovery well in Upton County, West, Texas. Nine miles southwest of the Flat Rock field, the new well is the No. 1 Ella M. Corbett. On potential test the well flowed 336 bbl of oil a day through 2-in. tubing, with gas-oil ratio of 530-to-one. Hole was drilled to 10,897 ft to get water in the Ellenburger, and plugged back and pipe perforated at 6130-60 ft.

Gas Well Is Compeletd In Mississippi County

Southern Production Company has completed a new gas well at its No. A-4 George W. Armstrong, in Wilkinson County, Southwestern Mississippi. The well flowed at the rate of 700,000 cu ft of gas on potential test plus 4 bbl of condensate per day through 10/64-in. choke. Tubing pressure was 1700 lb. Production is from casing perforations 5083-86 ft opposite the "4600" sand of the Wilcox formation. Hole was drilled to 7203 ft and cased with 5½-in. casing to 5198 ft for completion.

Texas Panhandle Well

Morgan and Head have opened a new oil pool in Morrison County, Texas, in the Texas Panhandle. It is the company's No. 1 Morrison, which topped the granite wash at 6410 ft. On a 3-hr drillstem test at 6950-80 ft, 2600 ft of clean 37-gravity oil were recovered.

Cities Service Gets Large New Mexico Discovery

Cities Service Oil Company has a new discovery in the Devonian formation, Lea County, New Mexico. It is the company's State AD No. 1 wildcat which flowed at the daily rate of approximately 2000 bbl of high gravity oil during a 4-hr test. The well flowed 329 bbl of 44 degree gravity oil in 4 hr, on a drillstem test at 9835 to 9860 ft, with a penetration made 27 to 52 ft in the Devonian limestone. The Devonian sand is the most prolific producing formation in the Cross Roads fields of north and west Lea County.

Texas Oil Field Opens

A new discovery has been completed in the Mississippian zone in Throckmorton County, Texas, by Pan American Production Company. It is the company's No. 1 J. B. Matthews, which flowed 189 bbl of 42.8 gravity oil daily through 16/64-in. choke, perforating at 4602 to 4608 ft. Gas oil ratio was 1160-1. Well was drilled to 4913 ft and has been plugged back to 4613 ft.

Derby Lindas Opens Field

Derby Oil and Lindas Oil Company have opened a new oil field in Stafford County, Kansas, at their No. 1 Schultz. The well flowed 13 bbl of oil for 3 hr, swabbed 14 bbl hourly, and then flowed 46 bbl of oil in 4 hr from the Lansing through perforations at 3603-07 ft. Lansing was topped at 3480 ft, and total depth was 3968 ft in the Arbuckle.

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Running Tour With Men in the Industry

James F. Neill has been promoted to assistant division manager, Rocky Mountain division of The Texas Company's producing department. Neill, a native of Denver, Colorado, is moving up from general superintendent of drilling and production, West Texas division, and in this new assignment will move from Fort Worth to Denver. He is a graduate of the Colorado School of Mines, with a B. S. degree in petroleum engineering. He joined The Texas Company in August, 1935, at McCamey, Texas.

He was promoted to general superintendent of drilling and production, West Texas division, last February.

Harold L. Geis

Harold L. Geis, formerly division geologist for Barnsdall Oil Company and more recently associated with the consulting firm of The R. B. Mitchell Company, has opened offices in the Esperson Building, Houston, Texas, as a geological consultant.

Geis has been active in Gulf Coast geology since 1935, when he was first employed by the Shell Oil Company. He spent the years 1939 to 1941 with the Atlantic Refining Company studying surface and subsurface geology in Cuba.

After graduating from the University of Illinois in 1933 Geis spent two years on a research fellowship in the graduate school at Chicago University.

Charles De Blieux, independent oil operator, has been named president of the New Orleans, Louisiana, Geological Society. Other officers elected for a one-year term are: **W. K. McWilliams,** Superior Oil Company, vice president; **Orval W. Noland,** Humble Oil and Refining Company, secretary, and **Lewis P. Kilbourne,** The Texas Company, treasurer. Elected for a three-year term as director was **Les Bowling,** independent operator.

George M. Washington has been named general manager, oil development department, of Northern Pacific Railway Company. Washington has been landman in the oil development for the last several months. He previously was employed by Standard Oil Company of California in the land department.

G. E. (Jerry) Hendrickson of Oklahoma City has been transferred to Bartlesville as head of Cities Service Oil Company's oil production division reservoir engineering section, according to an announcement by J. A. Cleverley, manager of the company's oil production division.

Hendrickson was first employed by Cities Service in 1933 after graduating from the Colorado School of Mines with a degree in petroleum engineering. His first assignment was with the oil production division at Oklahoma City. He was transferred to Seminole in 1936 as district engineer and, in 1941, joined the armed forces. After completing his army duty, he returned to Oklahoma City as assistant division engineer and, later, was elevated to the post of division engineer.

Henry B. Beard, assistant foreman in Magnolia Petroleum Company's Falfurrias, Texas, producing district, has been promoted to production foreman of the company's Brownfield district in West Texas.

Garland C. Rutherford, production foreman in Magnolia's Brownfield district, has been transferred to the company's Pegasus producing district.

Ernest W. Hardt has been made assistant production foreman in the Falfurrias producing district. Hardt has been an assistant foreman in the Alice producing district.

Robert J. Bradley, John A. Crichton, and Associates have announced the formation of a partnership to be known as Bradley, Crichton, and Associates. They will serve as consultants in geological engineering, exploration, evaluation, and financial matters pertaining to the oil and gas industry.

R. M. "Bob" Pyles, general superintendent of Southwest Exploration Company of Huntington Beach, and founder of the R. M. Pyles Boys and Girls Camp for underprivileged children of California, was the recipient of a beautiful hand-lettered scroll from the Los Angeles City Council recently. The scroll was inscribed with a resolution passed by the Los Angeles City Council commending Pyles and people of the petroleum industry, who sponsored the project, for their philanthropic contribution to juvenile welfare through the program at their summer camp in the Sierra National Forest.

Co-hosts for the party were **F. E. Fairfield,** Oil Tool Corporation, and **W. A. Smith** of the W. A. Smith Company, both of Long Beach.

Guests included **S. F. Bowlby** and **Carl Totten** of Shell Oil Company, **R. H. Green** of Signal Oil and Gas, **J. M. Hillman** of Hillman-Kelley, Inc., **L. L. Hillman** of Loren L. Hillman, Inc., **F. A. Morgan** and **George Randall** of Richfield Oil Corporation, **W. G. McComiskey** of Signal Hill Electric Company, **G. C. Pilkington** of The Texas Company, and **R. C. Schweitzer** and **L. C. Graves** of Southwest Exploration Company.

E. C. Wells, Jr., Matoon, Illinois, has been appointed chief petroleum engineer of The Carter Oil Company, and **W. F. Eiting, Jr.,** has been named production superintendent for the Eastern division, Matoon. Wells joined Carter in 1936 as roustabout, immediately upon graduation from Louisiana State University. He has been assistant division production superintendent since 1948.

Eiting, University of Tulsa graduate, has been with Carter 17 years. He was made chief petroleum engineer in 1948.

Visitors at the New York Chapter of Nomads party at the Stork Club in New York City recently included this group: Harry Kerr, Gulf Oil, Tunisia; J. R. Johnson, I.G.E.S.A., Bogota, Colombia; W. O. Woelgesy, Texaco, Caracas, Venezuela; Ian Herrera, Trinidad Oilfield Service, Ltd., Trinidad; George Broadbent, General Motors Overseas Corporation, Karachi, Pakistan; Frank King, The Texas Company, Caracas, Venezuela, and H. A. McGurty, Standard Oil of California, San Francisco.

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1

All free pipe can be removed from the well before it has a chance to stick further up the hole. A common occurrence if action is not taken immediately. The McCullough Magna-Tector and String Shot locate the lowest free point and loosen all free pipe in a matter of hours compared to the days needed by other methods. For example: Drill pipe was stuck at 10,600 feet. The Magna-Tector located the stuck point just above the drill collars. A String Shot loosened the first joint above the stuck point and pipe was recovered without damage. Total time was three hours and 55 minutes.

All Free Pipe Recovered In Two Easy Steps

2

First, the Magna-Tector locates the stuck point—within inches—within minutes. Second, the String Shot loosens the first joint above the stuck point. All free pipe is recovered at one time. For example: An operator estimated the stuck point of his drill pipe to be at about 4200 feet. However, the Magna-Tector located the stuck point at 5362 feet. The String Shot loosened the first free joint at 5350 feet. All free pipe was recovered at one time. Actually, the operator received a bonus of 1150 feet of pipe he didn't expect to recover so easily and subsequent fishing operations were simplified and speeded.

Magna-Tector Saves Fishing Jobs

3

The Magna-Tector not only locates the stuck point in drill pipe, casing, or tubing, but many times indicates the sticking medium, and in some cases working and/or spotting oil in the tight place indicated by the Magna-Tector, has freed the pipe. This is a fairly common occurrence and has eliminated many fishing jobs. For example: Drill pipe was stuck at 8340 feet. The Magna-Tector located the stuck point at 6540 feet. However, the Magna-Tector indicated that the pipe was frictionally held by compacted shale or sand. Working the drill pipe loosened the string, freeing it deeper and deeper down the well until all the drill pipe was free. The Magna-Tector and immediate action saved the operator many hundreds of dollars.

Unusual Jobs Accomplished

4

The McCullough Magna-Tector and String Shot save the operator untold hours of rig time because of their ability to perform the tough, unusual jobs. Jobs such as back-off operations through the restricted I.D. of fishing tools, production packers, etc.—operations in high angle holes—operations under excessive pressure and temperatures—and many others. For example: An operator's tubing was stuck in 7" casing. The Magna-Tector revealed that the packer was stuck. A fifteen foot String Shot, 200 grains of explosive per foot, was placed through the body of packer and detonated. Packer came loose immediately. There was no damage to tubing or packer.

No Substitute For Experience

5

Over 10,000 jobs, successfully completed, make up McCullough's backlog of experience in back-off operations. Our equipment is the most efficient and dependable available. Our Servicemen have wider experience in back-off operations than any other group of men in the oil industry. They are specialists—specialists in getting pipe out of the hole in the fastest possible time at the least possible cost—specialists in saving you time, money, and pipe.

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Running Tour

H. H. Kaveler, assistant manager production department, Phillips Petroleum Company, has resigned to engage in business for himself in Tulsa, Oklahoma. **L. E. Fitzjarrald** will continue as manager and **John Houchin** as general superintendent of the department. The position of assistant manager will be discontinued.

Jack Tarner, now chief reservoir engineer, has become technical advisor to the manager and will be in charge of reservoir studies, unitization and proration.

Donald I. Lawless, chief geologist for Bishop Oil Company, will supervise the exploration program of Bishop's Canadian subsidiary, Canadian Bishop Oil, Ltd. He will work with assistant manager Ross Anderson and geologist Rex Barnes of the Canadian firm. Their headquarters are in the Bamlett Building, Calgary.

W. B. Hayes, formerly drilling superintendent of International Petroleum Company in Peru and Colombia, has accepted a like position with Dunlap and Graham Drilling Company, Inc. He is now in charge of the company's drilling operations in Colombia, according to D. H. Graham, president. Dunlap and Graham spudded in its first well for Interco in the Barranquilla area in Colombia on September 2, 1952, and is drilling ahead at 5000 ft.

H. Wayne Holyman and **William L. Morris** have announced the formation of Holyman-Morris, consultants in the petroleum and mining industries, seismic aeromagnetics, radioactivity surveys, and production engineering. Offices are at 816 West Fifth Street, Los Angeles, California.

R. N. Freehling was advanced to district petroleum engineer at Casper, Wyoming, engineering department, Rocky Mountain Division of The Texas Company, replacing **John B. Flugstad,** resigned. In this new position Freehling will be responsible for petroleum engineering activity in Wyoming, northeastern Colorado, and southwest Nebraska.

J. B. Ladd was promoted to the position of district petroleum engineer at Craig, Colorado, and his territory will include northwest Colorado.

Freehling is a petroleum engineering graduate of the University of Pittsburgh. He was first employed by The Texas Company as a roustabout in the Rangely field, Colorado, and he has since that time held petroleum engineering positions in northern Montana and northwest Colorado.

Ladd is a petroleum engineering graduate of the University of Kansas. He was employed by Texas Company as a petroleum engineer in northern Montana. He later was assigned to the Wyoming district office.

A. W. Black has been named division geophysicist at Billings, Montana, for Continental Oil Company. He was formerly supervisor of the Rocy Mountain Geophysical section of Conoco.

Kenneth E. Burg, vice president of Geophysical Service, Inc., and **Roy L. Lay,** manager, geophysical division of The Texas Company, head the ballot as nominees for president of the Society of Exploration Geophysicists for the 1953-54 year. Aspirants to the office of vice president are **Dr. Karl Dyk,** chief geophysicist of Stanolind Oil and Gas, and **Eugene W. Frowe,** laboratory chief for Robert H. Ray Company. **W. B. Robinson,** geophysical supervisor for the Tulsa division of Gulf Research and Development Company, and **Bart W. Sorge,** vice president of United Geophysical Company have been nominated for secretary-treasurer.

For the two-year term as editor **Dr. Milton B. Dobrin,** senior research physicist for Magnolia Petroleum Company, will oppose **Dr. L. Y. Faust,** geophysicist for Amerada Petroleum Corporation, Tulsa. Additional nominations may be made by petition of active members of the SEG, according to Curtis H. Johnson, of General Petroleum Corporation, Los Angeles, president of the society and chairman of the committee on nominations.

Tennant J. Brooks

Tennant J. Brooks has been named geologist for the Franco Western Oil Company. Brooks came to Western from Standard Oil Company of California where he had been employed as a geologist for the past five years. Prior to his employment by Standard he was associated with Ferguson and Bosworth in Bakersfield. His undergraduate training was received at the University of California at Los Angeles from which he graduated in 1941 with an A. B. degree in geology.

G. T. Pearson has been promoted from manager of production to assistant general manager of the central region for Continental Oil Company. He succeeds **Harold S. Skinner,** who was transferred to Fort Worth as assistant general manager of the southwestern region. Pearson joined Continental in 1931 at Seal Beach, California, went to Fort Worth in 1949 as assistant regional manager of production, and to the Oklahoma City offices in 1950.

Harry Hurd has resigned his position as assistant regional geologist for Continental Oil Company, to organize and head a geological and exploration department for The Hefner Company. He has been with Conoco nearly 10 years, and has been district geologist in Oklahoma City for the last four years.

W. G. Iverson, Kansas district geologist for Continental Oil Company for the last four years, has been named chief geologist for Derby Oil Company. A graduate of the University of Nebraska, Iverson has been active in Texas, New Mexico, Oklahoma, Colorado, and Kansas, since joining Conoco in 1941.

Joe A. Laird, geologist and petroleum engineer, has opened offices at 1006 San Jacinto Building, Houston, Texas. He will deal with geological and engineering reports, property valuation, management, and development.

C. M. Fischer, roustabout gangpusher, Friendswood district, Gulf Coast Division, was promoted to farm boss, and **R. H. Barrett,** roustabout gangpusher, was promoted to farm boss at Lovell Lake district, for Humble Oil and Refining Company.

Charlie G. Smith, roustabout derrickman at Raccoon Bend, Gulf Coast division, and **J. H. Pilgrim,** roustabout, Lovell Lake district, were promoted to roustabout gangpusher in their respective districts. Also promoted to roustabout gangpusher was **J. W. Fowler,** Hardin district, Gulf Coast division. He was formerly pumper and gager at Maurbro district.

George B. McCullough, division clerk, Louisiana division office, transferred to the research division, employee relations department, Houston, Texas, as research assistant.

Allen H. Illfrey, senior petroleum engineer, Houston office, transferred to the Southwest Texas division office as senior petroleum engineer.

David E. Franklin, regional employee relations manager, North Texas division, is serving as acting assistant manager of the employee relations department. During Franklin's absence from North Texas, which will be for approximately three months, **J. M. Beasley,** division head of the research section, will serve as acting regional employee relations manager for the North Texas Division.

James R. Dunn, acting assistant manager of the employee relations department for the past three months, returned to his regular job as regional employee relations manager in the Southwest Texas division.

C. C. Bankhead recently joined Avila Oil Company at Fort Worth, Texas. He had been a consultant at Abilene since 1946, and prior to that time had been with Shell Oil as exploration engineer and geologist.

Robert Horton, formerly geologist for Bishop Oil Company in Kansas, has been named engineering assistant to the general manager, with offices in San Francisco, California. **Burr M. Roberts,** senior geologist, has been transferred to Billings, Montana, from Scottsbluff, Nebraska.

Marvin E. Frankamp has been added to the company's staff as a geologist in Wichita, Kansas, and **Tex Luthy** has joined the staff as geologist at Bismarck, North Dakota.

Jet Engines and Their Fuels

ARCH L. FOSTER*

In the realm of aircraft primer movers the recent, war-time development of Captain (British) Whittle's jet engine has made "evolution" and "revolution" essentially synonymous. Significance of jet power in especially military aviation is indicated without question by the fact that, as J. B. Hill told the National Petroleum Association recently, "Development of large reciprocating engines has practically stopped."

Result of this trend is inevitably that jet fuel properties and availability, methods for manufacturing them, their utilization and the effect of various properties on fuel and thus engine performance, all these and numerous other factors are of the greatest importance to both the aviation and the refining industries. For a generation the oil refining, and the aircraft engine industry have been working to design fuels and engines that will show higher efficiencies, power that will drive planes faster. This fuel trend has taken the higher octane number (performance number), higher volatility direction with the result that numbers well above that of trimethyl pentane are required to fuel present-day reciprocating, piston-type engines.

In the accompanying group of articles representatives of the three industries—aviation, engine, and fuel—present the requirements for quantity of jet fuels, the specifications (properties) required in these fuels, how they can be made, the position of the (small) refiners in producing them, and the probable trend in commercial aviation power plants in the next 10 years.

In large measure the problems faced in jet fuels and engines center around two factors; engine design itself, as it affects property requirements for fuels; and the liberalization of specifications to increase the quantities of jet fuel available, to simplify the manufacture, but determining the critical limits of specifications, and to find out the properties of major importance from fuel performance and fuel manufacture viewpoints. The job challenges the mental capacity, the perseverance and the greatest efforts of all three industries.

Interestingly enough, the manufacture of jet fuels does not require any special equipment other than possibly careful fractionation capacity. It is mainly a matter of selection of crudes and of various fractions from those crudes, straightrun and in some measure cracked products, to obtain the maximum properties in those items of specification that have been found of primary importance in assuring satisfactory performance. The more severe these specifications are, the better the fuel quality is, but the more restricted is the fuel supply, a matter of lesser import in peacetime and at present, but a critical and deciding factor in case of all-out war.

Consequently, all specifications are compromises, not only between the different items in a given set, or specification, but between these two limiting factors, fuel quality and fuel availability. Properties of the fuels now made up by some 70 manufacturing points differ widely, and gradually the industry is learning the answers. Aromatics content must be limited to hold burner carbon deposition within permissible limits. Volatility must be controlled in order to prevent vapor lock and fuel loss by evaporation, and to make for easy starting and restarting, maintenance of uniform burning, and continuous flame.

Specifications for fuels formulated so far are shown in the paper by Dr. C. W. Kelley, who outlines in careful analysis the situation with regard to these fuels, conditions that will rule their production in peace or war. These facts must govern the oil industry in its production of jet fuels and its planning for their manufacture from available crude sources.

Of special moment is the changed position of the small and middle-sized refiner in the new aviation fuel picture, as shown by Krause herein in the paper "Jet Fuel and the Refiner." Highly complicated and expensive equipment and processes are not required; the small plant with suitable crude supply and adequate fractionation equipment can produce top-quality jet fuels by the application of the knowledge already gained as the parts played by the different components. Krause outlines five advantages recurring to the small refiner from the manufacture of jet fuels, all of which are important to his survival. For example, Krause states that a refiner may make jet fuels "in token amounts," or may convert up to 40 per cent of his total crude run to meet JP-4 specifications.

Jet fuel price is of relatively minor importance militarily speaking; adoption of jet engines by commercial aviation will depend in greater degree on the fuel cost to airlines, says J. Bennett Hill of Sun Oil Company. He decided that the price of jet fuel will be somewhat below that of regular motor fuel, but higher than the kerosine price, a reasonable deduction as jet fuel takes part of each product in its blending. Under existing motor fuel and kerosine prices Hill expects jet fuel to cost in the neighborhood of 10 cents per gallon as compared to aviation gasoline at 16.5 cents, on the Gulf Coast.

From the data presented in this symposium it seems obvious that the alert refiner cannot overlook the possibilities of production of jet fuel as part of his economy. Actually it is pointed out that motor fuel antiknock quality may be raised by relegating to jet fuel blending the low octane rating naphthas, as jet fuel needs no antiknock property. Obviously also, in case of war jet fuels can be made by the great majority of refiners with a minimum of time and cost for conversion of their operations to its production. * * *

*Editor, Refining and Gas Processing.

EXCLUSIVE

Aircraft Turbine Fuel Supply Problems†

Seventy refiners makes fuels for jets varying in properties. Military now uses 100,000 bbl per day

MAURICE L. GRANVILLE*

JET fuel supply problems are similar to many other problems in that they represent compromises between quality and supply. Before getting into the details of the specific compromises involved in jet fuels, the author would like to outline how PAD attacks problems of this type.

PAD has the responsibility of insuring that the essential military and civilian requirements for petroleum products are met. The problems involved in this assignment can be divided into short-term problems and long-range problems. The jet fuel supply problem is largely a long-term one although there has been a short-term problem, which will be covered later.

In attacking short-term supply problems, PAD attempts to locate available supplies and then to make arrangements to get the supplies to the market. Although we have legal authority to direct the supply of petroleum products to essential uses, we prefer to have the industry willing to make the supplies available. The industry's co-operation has been excellent.

A slightly different approach is of course used on long-range problems. Here, we just establish the magnitude of the problem and the new facilities if any needed by the industry. If facilities are required, a program is set up under which the industry can frequently obtain accelerated tax amortization on their investment. These programs are also supported by the allocation of the required materials.

The ability of industry to manufacture the large volumes of jet fuels that would be required in wartime is, of course, related to the need for increased capacity to produce, refine, and transport crude oil and products for all essential wartime uses. The wartime jet fuel supply problem is essentially a matter of making available from this over-all pool of petroleum products the necessary quantities of fuel of the best possible quality that can be provided under emergency conditions. We are not blessed with a situation where adequate supplies of fuel could be made available in wartime, which would perform ideally in all types of aircraft turbines. We do recognize that in making compromises between quality and supply we must do everything possible to contribute to the development of turbine driven aircraft through improvements in fuel quality.

PAD keeps advised of the performance problems related to fuel quality through contacts with industry, the National Advisory Committee for Aeronautics, the Armed Forces, and others. Many studies have been made of the availability of improved fuels, and we have advised the Department of Defense on these matters The result is that we now have specifications for improved turbine fuels we know can be supplied in adequate volume in wartime. It is reasonable to believe that such progress will continue.

The above described functions are carried out by the Refining Division of PAD. These advisors with their associates in the industry are the real contributors to the progress which continues to be made. We have two groups of industry advisors; a senior group from industry, known as the Military Fuels Technical Advisory Committee. Through these committees we have ready access to a very broad knowledge of refining technology. This assures responsible handling of complex problems, such as jet fuel availability. Many of the same individuals working on these advisory committees have served on earlier groups. These included the subcommittees of the Military Petroleum Advisory Board, which formerly served in an advisory capacity to Government.

It is extremely important that peacetime activities be intermeshed with wartime plans. By this we mean that fuels used to develop and operate engines today must gear into wartime availability. The present JP-4 specification represents such a fuel, but it is apparent that a rather wide range of fuel characteristics will fall within the limitation of JP-4 specifications. This is illustrated in Table 1.

Table 1. Representative procurement fuels vs. current JP-4 specifications.

	Current JP-4 specifications	Current procurement JP-4
Gravity, API	40—58	42—55
Rvp, psi	2—3	2.1—3.0
10 per cent evap., F	250 max	200—248
End point, F	550 max	450—515
Aromatics, vol per cent	25 max	7.0—17.5
Total sulfur, wgt per cent	0.4 max	.01—.38
Bromine No.	30 max	.1—5.0

In connection with Table 1 the following points are of most significance:

1. The majority of current JP-4 production east of the Rockies is 50 deg API and higher and that from the West Coast is predominantly between 44 and 50 gravity.

2. Very little JP-4 production exceeds 230 F at the 10 per cent evaporated point.

3. The low bromine numbers reflect the fact that currently JP-4 is predominantly produced from straight run stocks. There are spot cases, however, where cracked materials run as high as 50 per cent, essentially all of which is thermally cracked stock.

JP-4 has been manufactured for and purchased by the military since January of this year. There are about 70 different points of manufacture, and the properties of the fuel vary widely. This is due to a number of factors, the most important of which are crude source and manufacturing procedure. As a result of the wide variation in crude characteristics and available refinery equipment, it is inevitable that such variations in jet fuel characteristics will occur. As will be shown later, these variations would be even more pronounced in wartime. In wartime we must be prepared, because of logistic and strategic considerations, to produce maximum yields of jet fuel from individual refineries or from groups of refineries in any area. For this reason we must be very careful to refrain from making our jet fuel specifications too restrictive. It also follows that a considerable portion of the actual production will surpass the limiting quality as defined by the specifications in one or more ways. This type of situation is of course well-known to the petroleum industry, where the ultimate performance of a product becomes a matter of probability based upon the manufacturing control and the type and condition of the equipment in which the product is used.

When considering the effect of various specification changes upon jet fuel availability, it must be remembered that the nature of petroleum hydrocarbons is such that most specification points have an interrelation. For example, a reduction in total aromatic content would permit a narrower range in allowable specific gravity as a lower maximum aro-

†This and the following papers were presented at a symposium on Jet Fuels — Present and Future before National Petroleum Association, Atlantic City, New Jersey, September, 1952.

*Assistant director, refining division, Petroleum Administration for Defense.

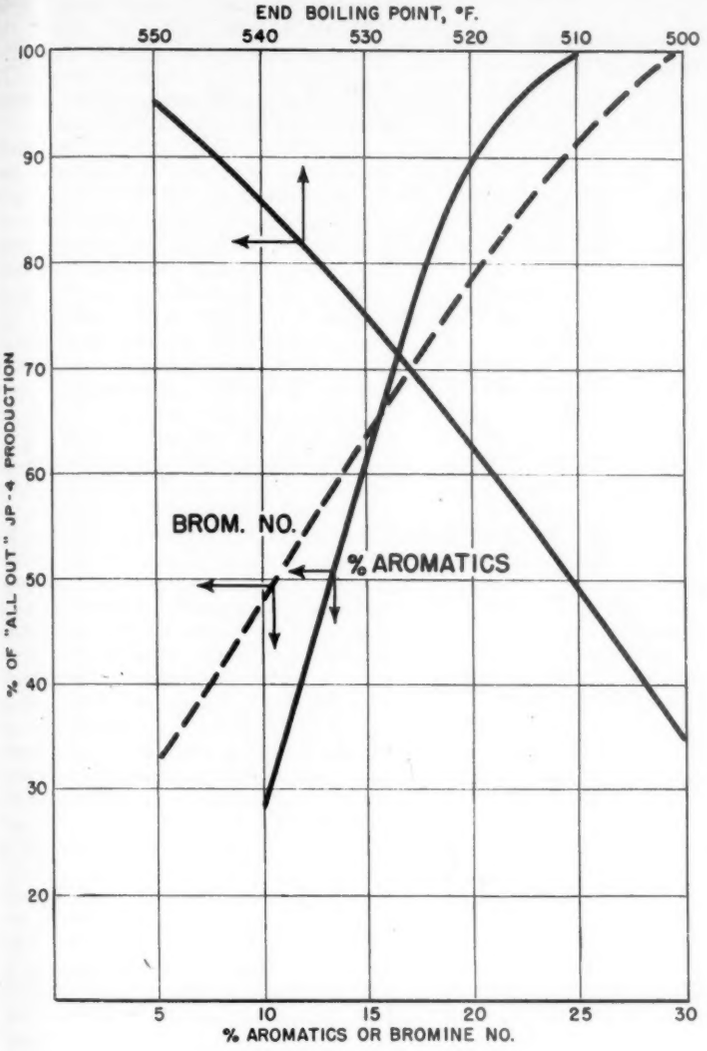

FIG. 1. Maximum effect of specifications on JP-4 availability.

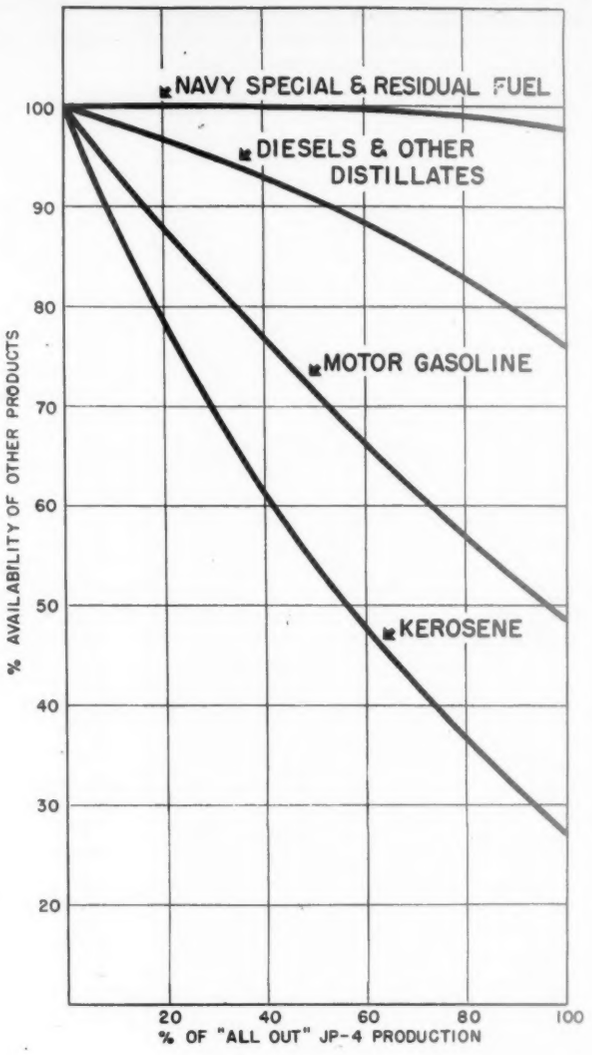

FIG. 2. Effect of JP-4 production level on availability of other products.

matic content would lessen the contrast between fuels produced from the various crude sources. In fact, almost any specification change that tends to reduce availability will permit some further narrowing of other specification points without a corrosponding further reduction in availability. Fig. 1 shows the effect upon "availability" of three JP-4 specification points, namely, maximum aromatics content, maximum end boiling point, and maximum bromine number. These curves show the "maximum" effect upon availability. They are based on discounting entire refinery output when that refinery cannot produce its present maximum yield of JP-4 fuel as a result of any proposed alteration to present specifications. In other words, these curves over-emphasize the reduction in availability from specification changes. They are then useful in establishing outside or maximum effects. Where more accurate estimates are required a detailed survey must be conducted of particular refining situations. Studies of this type were used in estimating the effect of going from JP-3 to JP-4, which included a reduction from 7 lb to 3 lb maximum vapor pressure, elimination of the maximum 90 per cent point temperature, and reduction of the maximum final boiling point from 600 F to 550 F. The combined effect of these changes was to reduce overall jet fuel availability by about 20 per cent. From these studies it is apparent that further reduction in maximum allowable vapor pressure cannot be tolerated.

Table 2 summarizes the major properties of JP-4 fuels under "all out" wartime conditions. In connection with Table 2 the following points are most important:

1. Due to the relative demands for the various major petroleum products during wartime, including the effects of rationing, we expect jet fuel to be lighter than it is currently, i.e., higher API gravity.

2. This factor is reflected also by the lower temperatures of the 10 per cent evaporated point.

3. The range of bromine number values is expected to widen very significantly under wartime conditions. The upper value is expected to approach the maximum allowed by present specifications, reflecting appreciable use of cracked stocks in jet fuels under wartime production.

A comparison of present day procurement fuels with maximum wartime production is shown in Table 3. This table combines the data given on Tables 1 and 2. In connection with Table 3 the following points—which were mentioned earlier when Table 2 was discussed—are worthy of restatement:

1. As compared with today, during an all-out war we definitely expect a pronounced shift within the gravity range of JP-4 toward a lighter fuel, i.e., higher API gravity.

Table 2. Representative "all out" JP-4 fuels.

	Current JP-4 specifications	"All out" JP-4
Gravity, API	40—58	44—57.5
Rvp, psi	2—3	2—3
10 per cent evap., F	250 max	160—230
End point, F	550 max	480—547
Aromatics, vol per cent	25 max	6.7—20.0
Total sulfur, wgt, per cent	0.4 max	.04—.38
Bromine No.	30 max	.8—30.0

2. Another indication of this shift is seen by comparing the front end volatilities of wartime and current JP-4 fuels. Also in wartime we expect that the average end point of jet fuels will be lower than in peacetime, although this is not shown on the table. The table is based on maximum possible production of jet fuel. Under wartime conditions the industry as a whole will not have to make maximum jet fuel. This relation of jet fuel to other distillate fuels in wartime will be discussed later.

3. We expect a very pronounced increase in the range of bromine number values in wartime, as compared with the present, reflecting an increased use of cracked materials.

4. You will note that practically every fuel inspection will have a wider range of values in wartime as compared with today. For this reason, it is most desirable that we keep the specifications of JP-4 as wide as possible in order to permit maximum flexibility of manufacture at a time when we know that demand upon specific areas may be several-fold greater than present production.

The effect of wartime production of JP-4 fuel upon the supplies of other petroleum products may be illustrated by Fig. 2. These plots show the relationship between the available supplies of four major petroleum products and the percentage of maximum United States JP-4 fuel production that wartime conditions may require. The assumption was made here that production of aviation gasoline would be maximized, at all levels of jet fuel production, since this product is more difficult to manufacture than JP-4 fuel. It will be noted that the product which will be affected the most percentagewise is kerosine distillate. Wartime jet fuels will contain from 75 to 80 per cent of motor gasoline (400 F) boiling range material and the remaining 20-25 per cent will be largely kerosine. Therefore, while the bulk of this fuel volume will come out of gasoline components, there will be a substantial amount coming out of kerosine distillate. As will be discussed shortly, it is apparent that there will be sufficient flexibility in wartime product distribution to split up available middle distillate components according to the need for these products for essential uses.

Table 3. Current procurement JP-4 vs. "all out" JP-4.

	Current procurement JP-4	"All out" JP-4
Gravity, API	42—55	44—57.5
Rvp, psi	2.1—3.0	2—3
10 per cent evap., F	200—248	160—230
End point, F	450—515	480—547
Aromatics, vol per cent	7.0—17.5	6.7—20.0
Total sulfur, wgt, per cent	.01—.38	.04—.38
Bromine No.	.1—5.0	.8—30.0

In wartime, the greatest volume of nonessential product that can be diverted to essential uses is motor gasoline. It is therefore appropriate that wartime jet fuels be supplied at the expense of this product. The wartime product supply balances indicate that we would have to continue operation of our catalytic cracking units but that adjustments would be made to supply, in the best manner, feed stocks for alkylation plants and base stocks for aviation gasoline blending. It would probably be necessary in many cases to blend catalytic cracked gasoline and distillates into jet fuels. The use of thermally cracked gasoline is not likely to be important because such equipment will be largely shutdown due to the need for large volumes of residual fuel in wartime.

It is thus apparent that in wartime the petroleum industry would, in a sense, have to go into reverse and figure out how best to "convert" motor gasoline into aviation gasoline, jet fuels, distillates, and residual fuels. It is further apparent that the degree of this situation would be such that distillates would be produced at minimum flash point, and residual fuels would be of much lower viscosity than normal. We are not concerned over the ability of the industry to produce satisfactory quality motor gasoline in wartime despite the large volumes of high quality stocks required for aviation gasoline blending.

As Doctor Kelley has already pointed out, there are a number of continuing performance problems related to jet fuel quality and availability. These include (1) gravity, and gravity range, which are important for operational reasons, (2) front end volatility, which may be important in altitude starting, (3) aromatic content, which affects burning quality and combustor deposits and (4) boiling range, which may also affect burning quality. PAD has recently advised the Armed Services that some specification changes were possible without significantly affecting availability. This advice was based on studies carried out by the Military Fuels Technical Advisory Committee. Specifically, we have suggested that it was possible to (1) change the gravity range from 40—58 API to 44—58 API, (2) lower the 10 per cent evaporated point from 250 F maximum to 230 F maximum and (3) lower the maximum aromatic content from 25 per cent to 20 per cent.

One of the most pressing current problems seems to be that of combustor carbon deposits. As we see it, this is largely a relative matter that assumes more importance as other turbine engine problems are overcome. This problem, however, is also associated with the development of higher output turbine engines. We in PAD are unable to predict the ultimate course of jet fuel specifications designed to mitigate this problem. Through the medium of our advisors from the petroleum industry we are studying the effect of proposed alterations in fuel quality designed to improve combustion and to alleviate related smoke and deposit problems. We do not believe that it will be feasible in our present mobilization program to count on making any substantial additions or alterations to refining equipment designed, for example, to reduce jet fuel aromatic content. Somewhere, short of this step, the problem must be solved by the engine manufacturers. At the same time it may later prove necessary and possible to tighten up on present JP-4 specifications to make sure that current fuels, and if necessary wartime fuels, are equal in burning quality to the MIL F-5161-B prototype jet fuel now being used for engine development work. This particular problem is now being studied by the Military Fuels Technical Advisory Committee. Current jet fuel supply presents another problem. While we have a large potential production of jet fuel, we do not have enough refiners equipped to blend jet fuel today. More refiners, especially those in coastal areas, should install equipment to segregate naphtha and kerosine fractions for use in blending jet fuel. Requirements for jet fuel have increased rapidly during the past year and are continuing to increase at a faster rate than any other military petroleum product. Current procurement by the military and by the engine manufacturers is approximately 100,000 bbl per day, and it is evident that these requirements will continue to increase for some time to come.

Summary: (1) we are using the knowledge and resources of the industry to determine the relationships between jet fuel specifications and jet fuel availability; (2) studies of jet fuel availability must consider the need in wartime to maximize jet fuel production at strategically located refineries; (3) the properties of wartime jet fuels will cover a wider range than those of peacetime jet fuels; (4) it is essential that wartime type jet fuels be available for engine development work, and (5) mobilization period jet fuel requirements are increasing rapidly. More refiners who can supply jet fuels are needed, especially in coastal areas, in order to increase availability to the military forces. ★ ★ ★

Refining Capacity Up

Although the total number of petroleum refineries in the United States decreased during 1951, the total crude-oil charging capacity continued to increase, according to a Bureau of Mines information circular released by Under Secretary of the Interior Vernon D. Northrop.

According to the survey, there were 350 refineries with a total daily crude through-put capacity of 7,332,885 bbl as of January 1, 1952, as compared with 357 refineries with a total daily capacity of 6,963,644 bbl a year earlier.

The Bureau's circular summarizes refinery and cracking plant capacity by years from 1914 to 1952, by states, and by districts, and report changes in crude oil capacity by districts from January 1, 1951, through January 1, 1952.

A free copy of Information Circular 7646, "Petroleum Refineries, Including Cracking Plants in the United States, January 1, 1952," may be obtained from the Bureau of Mines, Pittsburgh 13, Penna.

P 801.

Jet Fuel Specifications†

Must be developed along with engine design to reach highest performance

CARL W. KELLEY*

Jet propulsion is one of the oldest scientific discoveries. The first recorded account of it is given as 160 B. C. when Hero of Alexander wrote a book, the "Pneumatic," giving the first record of a device utilizing jet propulsion. The first evidence of any military agency using it is found to be around the beginning of the nineteenth century when the British, trying to improve their sea power, attempted to use jet propulsion to operate a ship, the "Water Witch." Its success was not too great. As a matter of fact a great many of the headaches the British had with jets in the early nineteenth century they still have today, and even have enough headaches to share some with the United States. Good evidence of this is the time we have spent attempting to develop suitable fuels for jets.

In this connection, and as far as the military is concerned, the development of a jet fuel appears to follow the pattern of other fuels that have qualified for military use. As in the development of diesel, automotive, and aircraft fuels, a fuel of the highest quality becomes the ultimate fuel. For example, the history of diesel fuel started with a very low grade fuel with few limiting control points in the specification. Today, the specification for diesel fuel has been developed until it is a high quality fuel and the development of premium grade automotive fuels and aviation gasoline has followed somewhat the same route. In the development of fuel for gas-turbine powered aircraft the same will be true. Regardless of the quality of the first types of fuel developed, economics and efficiency of operations together with engine design will dictate a high grade fuel.

Already various grades of jet fuel have evolved and the specifications have been changed for the reasons given above. Let us look at these jet fuel specifications and analyze some of the reasons why changes have been made.

The table is at right.

Specification MIL-F-5616, JP-1 fuel was the first fuel on which jet engines operated. Requirements included 110 F minimum flash point, 572 F end point maximum, –76 F freezing point and a smoking tendency requirement that dictated a high degree of paraffinicity in fuel composition. JP-1 seldom met the maximum end point due to smoking tendency and freezing point requirement. This was a narrow boiling range material of the kerosine type that comprised only (a small portion) of a barrel of crude oil. Because of this limited availability as well as engine starting difficulties at *low temperatures* JP-1 has become obsolete for military use, except for older models of jet powered aircraft. Jet engines for Navy use were developed on aviation gasoline, as necessitated by carrier application and because of impracticability of handling another type of fuel aboard carriers and in Navy oilers.

Grade JP-2, Specification AN-F-34 was an experimental fuel considered about four years ago but which was never adopted.

Specification MIL-F-5624, JP-3 fuel replaced JP-1 fuel for reasons of increased availability and better starting characteristics. This material was made of blends of gasoline and kerosine to give a product of 5-7 lb Reid Vapor Pressure, 600 F maximum end point and a maximum freezing point of –76 F. It was found, however, that a fuel of 5-7 lb vapor pressure gave excessive fuel losses from jet plane tanks in flight when (climbing) rapidly from hot normal atmospheric conditions to the rarified upper atmosphere. Vapor locking and slugging were also encountered. In order to remedy this condition, the vapor pressure was reduced to a minimum of 2 lb, and a maximum of 3 lb. This new fuel was incorporated into a new fuel called JP-4 or MIL-F-5624A. *This is the fuel that is currently being supplied to most aircraft.* The specification was written to premit *maximum* availability and at the same time give desired performance characteristics.

It is significant that these several changes, concluded in the space of only seven years, have been dictated primarily by logistical and operational requirements.

Specification MIL-F-5161B fuel, referee, aircraft turbine, and jet engine referee fuel for JP-4 specification, was written in order to insure that adequate consideration will be given to fuel quality variations in jet engine design during peacetime so as to be prepared for the relatively poorer fuel that will be produced in the time of emergency. The NACA Subcommittee on Aircraft Fuels, in cooperation with the aircraft industry prepared the recommended specification limits on the referee fuel. Likewise 5161 was written for JP-1 and 5161A written for JP-3 specification.

To outline more clearly why a referee fuel specification is required, possibly some comments should be made on manufacturing practices under peacetime and wartime conditions. Under peacetime conditions, only small quantities of jet fuel will be required. Under these circumstances, the majority of refiners will make a fuel to the specification in the easiest possible way, which usually involves the blending of available commercial products. In most cases therefore, the refiner will take those stocks least valuable to him as a motor fuel and either his current production of a No. 1 fuel oil or kerosine. The blending of such products will result usually in a fuel having a relatively low end point, low bromine number, low

	MIL-F-5616 Amendm't 1 25 July 50	MIL-F-5624A 23 Jan 51		MIL-F-7914 (AER) 11 March 1952	MIL-F-5161B 26 July 51
	JP-1	JP-3	JP-4	JP-5	Referee fuel
Freezing point F	–76	–76	–76	–40	–60
Corrosion cu strip	Pass	Pass	Pass	Pass	Pass
Residue or existent gum max mg/100 ml	5.0	10.0	10.0	10	10
Aromatic per cent max by vol	20	25	25	25	20
Total sulfur					
Max per cent by weight	0.20	0.4	0.4	0.5	0.4
Min	.....	.....	.....	.....	0.2
Mercaptan sulfur					
Max per cent by weight	.005	.005	.005	.005	.005
Gravity API					
Max	.....	63	58	50	58
Min	35	45	40	35	40
Vapor pressure psi					
Max	.....	7.0	3.0	.....	3
Min	.....	5.0	2.0	.....	2
Accelerated gum					
Max mg/100 mil	8.0	20.0	20.0	20	20
Distillation F					
10 per cent min evap	410	0	250	410	220
90 per cent min evap	490	.....	.....	550	450
90 per cent max evap	.....	400	.....	550	.....
EP max	572	600	550		
Residue per cent max	1.5	1.5	1.5	1.5	1.5
Distillation loss per cent max	1.5	1.5	1.5	1.5	1.5
Bromine number max	3.0	30.0	30.0	30	30
Bromine number min	.....	.....	.....	.....	5
Heat of combustion min btu/lb	.....	18,400	18,400	18,300	18,400
Heat of combustion max					18,600
Inhibitor lb/5000 US gal	.....	1	1	1	
Water tolerance					
Change in color allowed	.....	None	None	None	None
Max volume change per layer ml	2	1	1		
Acidity mg KOH/gm of fuel	.....	.....	.....	.....	.....
Color, Saybolt not darker than	+12	.....	.....	.....	.....
Flash point F min	110	.....	.....	140	.....
Viscosity CS at –40 F	10	.....	.....	20	.....

†Presented at Joint meeting, Department of Manufacture and Department of Standards and Tests annual meeting, National Petroleum Association, Atlantic City, New Jersey, September 11, 1952.

*Office of Petroleum Programs Munitions Board.

aromaticity, etc. Cracked gasoline stocks will not be generally used, inasmuch as they have more value than straight run stocks in motor gasoline blends.

Under wartime conditions, it is anticipated that the demand for jet fuel will be extremely high and will require ingenuity on the part of the refiner to maximize production by including various quantities of cracked gasolines and cracked fuel oil fractions. These will tend to increase bromine number and aromatics toward the limit of the specification—increase gum content, increase boiling range and sulfur content and decrease gravity and heat of combustion. It is therefore, important that engines designed for wartime use be built to handle the wartime fuel and not the easier-to-handle type of fuel available commercially in peacetime. The purpose of the referee fuel is to make such a fuel available for design and testing. Engine developement contracts call for referee fuels for primary qualification.

In considering the general requirements of jet fuels, availability heads the list as it is the most important from the military view point. Unless a fuel can be produced in sufficient quantities during an emergency, it is of little value no matter how exceptional it may be from a performance standpoint.

Third on the list of general requirements is the question of flammability or fire hazard. There is no such thing as a "safety fuel" because any fuel that will burn in an engine also will burn outside if given the right set of conditions. The important factors, however, are ease of ignition and speed with which fire spreads. Service experience and laboratory tests indicate big differences in this respect. It has been demonstrated that at an atmospheric temperature of 100 F the minimum 10 per cent ASTM distillation temperature should be approximately 350 F. In military operations considerations of availability and low temperature starting rule out the use of a less volatile fuel and a compromise is made on a fuel as JP-4.

The fourth requirement of jet fuels is low temperature properties as this is one of the most important factors in aircraft operations. Military operations require starting at atmospheric temperatures of –65 F or lower. Experience has clearly demonstrated that the –76 F now used in JP-4 fuel specification is a realistic figure and cannot be compromised without imposing severe operational limitations.

Volatility is another general requirement for jet fuels as it governs the evaporation slugging vapor locking, freezing point, cold starting, flammability, availability, and combustion characteristics. For these reasons volatility or its ASTM distillation limits must be clearly defined.

Stability is the sixth general requirement for jet fuels and there can be no compromise on its requirements. This means that fuels must remain stable during some of the most unfavorable conditions of storage. These storage periods in remote areas may often run up to two years. In some of these out-of-the-way locations, fuel supplies are moved in once a year during flood stage of streams and rivers. It is not uncommon to find stocks in these places with storage time from 1 to 2 years.

The seventh requirement for jet fuel is odor. All jet fuels should have a satisfactory odor. A mercaptan content of 0.005 per cent is now allowed for JP-4 specification. The purpose is twofold, first odor and second to prevent deterioration of the polysulfide type of synthetic rubber (Thiakol) used in parts of present fuel systems by mercaptan sulfur compounds.

It seems logical at this point to consider some of the problems encountered by the military in the use of present jet fuel specifications.

Current engine developmental work is primarily based on referee JP-4 fuel. In spite of this, however, the specification is known to be weak, due primarily to a lack of information concerning the composition, particularly back end composition of planned wartime marginal jet fuels. It is true that it is not desirable to be continually effecting changes in fuel composition but in this case there appears to be no alternative. Therefore, it is felt that it is a prime responsibility of the military services and industry groups to develop as rapidly as feasible, a sound developmental referee fuel specification. By balancing the design and availability factors, a realistic specification can be constructed.

Starting difficulties have been encountered in certain engines when using the low volatility JP-4 fuel. A number of laboratory investigations, however, have been made that indicate that low temperature starting characteristics can be markedly influenced by combustion and ignition system design.

The wide permissible gravity range of the JP-4 specification has been the subject of much adverse criticism from the standpoint of its effect on fuel controller operation. These devices which govern and schedule the flow of fuel to the combustor contain no continuous adjusting mechanism but instead are set to one average fuel density. Obviously, the operation of such single setting controllers is sensitive to variations in viscosity and API gravity; variations are further magnified by the changes in fuel temperature which occur during flight. Although research directed toward alleviation of this problem is currently being conducted, no quick solution is forecast. Consequently, not only current service aircraft but also a considerable number yet to be produced will be affected by this control deficiency.

To minimize both the service operating problem and the amount of research effort facing the controller manufacturer, it is desirable that the gravity range specified be no greater than that required to insure ample availability.

The suggestion has been made that there be a number of referee fuels instead of one, since it must embody all minimum requirements and one fuel may not be able to do this.

Deposits left on an engine from combustion are the most pressing fuel-related problem facing the services and engine manufacturers today in the design and operation of jet aircraft. Certain service engines have demonstrated decreased performance when operating on marginal JP-4 fuel. This is manifested by poor acceleration characteristics, uncertain ignition and spark plug operation due to carbon accumulation in the dome areas, and decreased liner life caused by warpage resulting from uneven temperature profiles across the combustor liner when carbon deposits are present. Since substantial numbers of these engines are already installed in planes in the aircraft programs of the Air Force and Navy, there is a question as to whether the propitious course of action is to undertake a costly, time consuming redesign of combustors or to amend the production JP-4 specification to alleviate the deposition problem. A major determinant is the logistical one; (i.e.) to what extent is the potential availability of JP-4 diminished by specification changes sufficient to permit satisfactory operation of the marginal engines?

Paraffins, olefins, and naphthenes, even those boiling up to and above the current 550 F end point of the specification do not appear to cause deposition problems. Sulfur also appears to have little effect. The multi-ring higher boiling aromatics, however, appear to markedly increase deposition. The degree of deposition is apparently a matter of molecular structure. As the aliphatic substitution increases, the deposition decreases, that is, in order of decreasing deposition tendency; Benzene, toluene, ethyl benzene, propyl-benzene, etc. Therefore, for the long run, it appears that control of deposition through specification restriction of total aromatics and/or end point is not desirable as such restrictions also eliminate fuel constituents of excellent burning quality. Development of adequate tests of over-all hydrogen carbon composition and of heavy polymers is needed.

Stability in storage of jet fuels is a matter of primary importance and one for which an adequate test method is needed. A fuel that can be stored indefinitely without deterioration is the goal. Some stability tests are now being made, but no results have been made known as yet. A problem related to stability arises from the fact that, unlike other fuels, JP-4 cannot be downgraded or blended with motor gasoline or fuel oil; if JP-4 deteriorates in storage, it must, if it is to be utilized, be returned to a refinery, thus increasing the burden on refining and transportation facilities.

Present test methods do not accurately measure existing gum. It would be advantageous to know whether present engines could tolerate a higher gum content, both from the standpoint of possible increased availability and from the standpoint of utilizing fuel that has been stored for a sufficient period of time to allow for an increase in gum content.

An accurate vapor-pressure test for 2 to 3-lb jet fuel is needed. Present test equipment is not adequate.

Some work has been done on the

cloud point of jet fuels but this properly should be more seriously considered as a pertinent characteristic. The cloud point may be used to indicate the temperature at which serious interference with fuel flow is likely to occur.

In the jet fuel specifications three inhibitors are listed that may be added separately or in combination to the fuel. These inhibitors are the same three as given in the aviation gasoline specifications and are used because of satisfactory performance in aviation gasoline. Investigation is under way, however, to determine what type of inhibitors are best adapted to jet fuels.

A projection into the future in connection with proposed specification changes for jet fuels could be a possible relaxation of the –76 F freezing point. This would mean a heavier and narrower gravity range jet fuel for heavy type aircraft without sacrificing availability. This would require a great deal of study from the fuel availability and logistics standpoint. If other changes are made in JP-4 specification they will probably be concerned with API gravity range, the 10 per cent distillation temperature, and the total aromatics content. Also aromatics boiling above 400 F may be considered.

As stated at the beginning, in the development of all military fuels a fuel of the highest quality becomes the ultimate goal. As the various jet fuel specifications are evolved, and engine design improved, the fuel that will be finally developed is the one which is developed along with engine design whereby the two combined factors of fuel and engine give the optimum performance. * *

Jet Fuel and The Refiner†

W. F. KRAUSE*

UNTIL recently the manufacture of aviation fuel has been confined almost exclusively to the large, major refiners. This was necessary because the reciprocating aviation engines require a fuel that can be produced only on expensive, specialized equipment such as alkylation or hydroforming units. As a result, the small refiner has confined his operations to civilian products and has played little part in aviation gasoline manufacture up to the present time. As an exception, some of the small refiners made a valuable contribution during World War II by the manufacture of cumene and codimer in poly plants. Even in these cases the volume was extremely small compared to the production of aviation gasoline from major companies.

The advent of the jet engine has brought about a major change in the aviation fuel industry. The jet engine has made it possible for the small refiner to participate in the defense program and to produce aviation fuel for these modern planes. The refining facilities of the small plant are adequate and suitable for production of most of the grades of jet fuel. Each operator should survey his facilities and determine what the production of jet fuel can do for him as well as what he can do for the defense program. There are certain advantages to the refiner in the production of jet engine fuel that should not be overlooked.

1. It gives additional diversification of products and opens new markets.
2. It will put the refiner in an advantageous position for supply of jet fuel to civilian commercial air lines when that new, future market develops.
3. In case of national emergency the production of jet fuel will be an aid toward continued crude supply and operation of the small refinery.
4. It increases the importance of the small refinery by production of jet fuel and thus serves as an aid to the expansion and improvement of small refinery facilities.
5. By use of low octane straight run gasoline and naphtha in jet fuel, a refiner can improve the octane level of his gasoline base stocks and decrease the amount of tetraethyl lead required for motor gasoline.

Many refiners are not familiar with these new aviation fuels and have not investigated the jet specifications. There are currently three types of jet fuels in production and use.

Referee Jet Fuel. A specialized fuel requiring unusual ingredients. The referee fuel is very necessary to the testing and development of jet engines but it does require special ingredients to meet its requirements and production is now confined to the major refiner. It is doubtful if the small refiner has either the ingredients or the desire to make such a fuel.

In this modern day, however, there is not the gap in facilities between the major refiner and the small, independent manufacturer that there was 10 years ago. In fact, many new processes have been pioneered and built first in small refineries and then adopted by the major companies. Therefore, those refiners interested in referee jet fuel should obtain a copy of Specification MIL-F-5161B from the Commanding General, Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, and determine in their own laboratories whether or not they have the ingredients suitable for production of this fuel. Production of referee jet fuel requires well fractionated ingredients where each component imparts certain properties to the completed blend. A stabilized natural gasoline is required for volatility control; straight run gasoline and naphtha for distillation; a stable thermal cracked gasoline or catalytic cracked gasoline for aromatic content. To bring the aromatic content up to minimum 20 per cent it is necessary to add toluene or xylene in most cases except where high aromatic West Coast crudes are used. Kerosine is added to control additional points of distillation specification. Sulfur content of minimum 0.3 per cent is a problem for all except those refiners operating on high sulfur crudes. There are so many points of control in the specifications that it is difficult to fall within the prescribed limits at all points when the ingredients are put together. Thus it can be seen that referee fuel is a specific case to be studied by each refiner.

Grade JP-4 is the fuel currently being supplied to most jet aircraft and it is this fuel which should be most interesting to the small refiner. An examination of Specification Mil-F-5624A shows that it is extremely lenient as contrasted with the rigid requirements for aviation fuel for reciprocating engines. The vapor pressure limits the amount of volatile components while the freezing point limits the amount of kerosine or distillate in the blend. Between these points there is wide latitude. The refiner can produce jet fuel in token amounts or make up to 40 per cent of his crude run while still meeting the JP-4 specifications. The specifications are sufficiently broad so that the average refiner can make JP-4 with little or no changes in stabilized gasoline or kerosine streams. This jet fuel does not require special ingredients and it can be readily produced by any refinery now making motor gasoline and burning oils.

The simplest topping unit with a single crude fractionating tower is potentially a source of supply of jet fuel. All that is required is to take a light gasoline fraction overhead and then withdraw naphtha and kerosine fractions as side cuts from the tower for use as jet fuel. Side cut strippers are not required because the jet fuel requires suf-

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ficient volatility to produce minimum 2-lb vapor pressure and the presence of small amounts of light ends is required. This is an extremely simple case and probably does not represent a true picture of operating facts because, actually, it is doubtful if any refiner will convert to 100 per cent production of jet fuel to the complete exclusion of naphtha or kerosine production. The case is cited to show that no facility is too small to be considered as a jet fuel manufacturer. In most cases jet fuel will be incorporated into the operation with continued production of decreased amounts of gasoline solvent naphthas and kerosine.

Grade JP-5 is the newest grade of jet fuel and many refiners may not be familiar with it. The specifications are covered by Mil-F-7914 (AER) available from the Commanding Officer, U. S. Naval Air Station, Johnsville, Pennsylvania, Attention — Technical Records Division. Production of this fuel will come entirely from the kerosine and burning oil fraction and will have no bearing on the gasoline yield of quality as does JP-4. In many cases the refiner's regular grade of kerosine will meet all of the requirements for JP-5 jet fuel. Each refiner should evaluate the production of this military fuel against his regular market for kerosine and burning oil.

At the present time, and probably for some time to come, the principal demand is for grade JP-4 jet fuel. It is this fuel the refiner should study most closely. Essentially it is a blend of stabilized gasoline, naphtha, and kerosine. In case of emergency, with large requirements to be met, it would be necessary to use both cracked and straight run products to meet the volume demands. Under normal conditions the refiner can select the straight run products for the jet fuels. This has the advantage of making a more stable jet fuel as well as removing the low octane ingredients from the motor fuel stocks. This point of increasing the octane level of base stocks for motor gasoline by using the straight run for jet fuel should be taken into account when evaluating the economics of jet fuels against gasoline and burning oil production.

Jet fuel is easily manufactured and no special treating facilities are required. The fuel does not have to be doctor sweet but the mercaptan content must be below 0.005 per cent. On many stocks a caustic wash will meet this requirement. If the fuel is sweetened by the doctor process, care must be taken in the treating to prevent a corrosive product. The corrosion specification is important and Air Force inspectors watch it very closely. If the refiner exercises care in treating, however, there will be no difficulty. All of the inspection tests are relatively simple and require no extraordinary equipment. The average small refinery laboratory will have no difficulty making the required control tests on the jet fuel. No expensive, special knock test engines are required because jet engines have no octane requirements and therefore the fuels have no octane specifications. The only piece of equipment the small refiner may not have in his laboratory prior to jet fuel manufacture is the steam jet gum apparatus. This new apparatus is now being used for evaluating diesel fuels and burning oils and will soon be necessary in all laboratories the same as the ASTM air jet gum bath, which is now in use for gasoline testing. Therefore, laboratory facilities should present no problem.

The refiner may have to make certain changes in operation to produce jet fuel and will have to take certain precautions to insure the quality after the fuel is blended. The stocks selected should be clean and well fractionated to give a low steam jet gum residue. This will be of increasing importance as more prevaporizing jet engines come into use. The gasoline stocks included in the blend should be stabilized to about 5 lb vapor pressure in order to meet the minimum 2 lb-maximum 3 lb vapor pressure specification of the JP-4. The blending of gasoline, naphtha and kerosine can be done either before or after treating, whichever is best suited to the facilities. The gasoline stocks can be copper sweetened and the kerosine stocks doctor treated without harm to the finished jet fuel.

The tanks and lines should be arranged in such a manner that the system can be isolated and sealed after the blend is completed, inspected and approved. There should be a separate loading line so there is no possibility of contamination by other refinery products. A separate loading and transfer system is desirable from the refiner's standpoint because it insures there will be no contamination of refinery gasoline or burning oils by the jet fuel. Jet fuel can not be handled through refinery lines used for other products because it is too heavy for gasoline and will spoil the flash point on burning oils. There is the added disadvantage to jet fuel that if a blend is off-specification and can not be approved for shipment there is almost no alternative except reprocessing it as slop oil. Therefore, it is important that the refiner be sure the components are right before putting them together to make the final jet fuel blend.

Tank cars, trucks or barges should be clean, dry and approved before loading. Because this is an aircraft fuel every precaution must be taken to deliver a clean, dry fuel to destination. For truck or tank car loading there should be a filter in the loading line to remove rust particles or any other foreign materials. A filter is not deemed necessary when loading barges at the refinery because such cargoes usually go into intermediate storage before delivery to the aircraft. Presumably the fuel is then filtered when delivered to final destination.

In general, it appears that jet fuels are truly the small refiners' aviation "gasoline" and these refiners can help themselves and the defense effort by the production of these fuels. At the present time, and particularly since the oil strike of last May, the shortage of motor gasoline makes the production of jet fuel somewhat unattractive to the refiner. On the long range consideration of probable increase in jet aircraft requirements as well as balancing of motor fuel stocks, the picture is much more in favor of the production of jet fuels. In any event, the jet fuel market must compete with motor fuel, solvent naphtha, and burning oil markets in order to be assured of supply in a civilian, peacetime economy. The federal procurement agencies should not overlook the small refiner as an advantageous, dependable, and well distributed source of supply for jet fuels under both peace time and war time conditions. ★ ★ ★

Britain's New Oil Refinery Ahead of Schedule

The new oil refinery being built at Coryton on the Thames 25 miles east of London will probably begin distilling crude oil before the end of this year, according to reports from Britain. The date has been moved forward from 1953 because of the progress made on this Anglo-American enterprise begun about two years ago.

The refinery is owned by the Vacuum Oil Company Limited, and is being financed equally by the British Powell Duffryn group and the American Socony-Vacuum Organization. A $34,000,000 project, it is expected to process about 5,950,000 bbl of crude oil annually, an important addition to Britain's expanding oil capacity. (The overall U. K. target for 1953 is 185,500,000 bbl compared with the output of 114,800,000 bbl in 1951.)

Coryton will be one of the few refineries in the world designed mainly for the manufacture of lubricating stock oils. It will use oils derived mainly from the Middle East, and the deep water available alongside the refinery means that there will be no difficulty in accommodating the giant tankers bringing in crude oil. By manufacturing products which are now largely imported, the refinery will effect a big dollar saving. Another important aspect of the Coryton site is the tankage, with capacity for storing 1,400,000 bbl of oil.

The processing units will include all that is most modern in petroleum refinery practice. An integral part of the plant will be a Thermofor Catalytic Cracking unit designed to improve the quality and increase the quantity of gasoline produced. This unit will be the first catalytic cracker of its type built in the United Kingdom, and the second in Europe. Its operation requires hot catalyst to be circulated within the unit at a rate of 2100 bbl an hour.

The refinery will include a mechanical workshop, warehouse, office building, laboratory, loading racks, garage, and canteen. Over 700 men and women will be employed.

P 801.

Suitability of Jet Fuels

E. A. DROEGEMUELLER*

It is the object of this paper to emphasize some of the problems involved in the complex balance between fuel suitability and turbine engine design, stressing the fact that we, as an engine manufacturer, endorse a policy to design and develop turbine engines capable of utilizing fuels having a broad boiling range and liberal specifications.

Past history has shown that the selection of fuels for aircraft power plants has been primarily based on the consideration of engine requirements, availability being of secondary importance as demonstrated by the small production of high octane fuel at the start of World War II. A series of compromises is the normal process by which industry arrives at a group of fuel properties which describe a satisfactory fuel quality for a given use. This process is evolution rather than revolution. There are many problems pertaining to aircraft fuels which need to be examined particularly when we realize that the jet aircraft is basically a military weapon and that jet fuel is therefore a munition of war.

*Pratt-Whitney Aircraft, Division of United Aircraft Corporation.

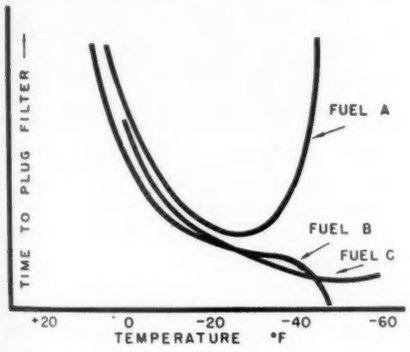


FIG. 1. Low temperature filter characteristics.

There are a few general rules that it might be well to establish concerning the functions that are necessary to fulfill in order to have a satisfactory airplane that includes the engine, airframe, and the fuel it must carry. A turbine fuel should have the following main qualities:

1. The fuel must be delivered to the engine under all operating conditions in the quantities required under all power operating regimes.
2. Starting must be quick and it must be accomplished at the lowest temperature which will be encountered.
3. Combustion must be efficient and stable under all conditions.
4. The fuel must not leave harmful residues in the combustion chamber or cause harmful effects on the engine parts.
5. If possible, it should have "safety" characteristics.
6. It should allow the smallest possible combustion chamber.

The relationship of some fuel properties to the above items as a group will now be discussed.

To fulfill one of the first requirements that all fuels must meet, i.e., the fuel must be capable of being delivered to the engine under all operating conditions in the quantities required under all power operating regimes, it is necessary to look into the filtering characteristics of the fuel. The author realizes that the ultimate goal would be to eliminate the filters entirely from jet engines but this cannot be done until we are sure that clean fuel will be delivered to the aircraft at all times. Thus, the filter clogging problem is one of importance.

Because of this requirement for a filter to remove dirt, we have an accompanying problem of filter clogging caused by the freezing or solidification of certain hydrocarbons in the form of waxes in the elements of the filter at low temperatures. A considerable research program on this type of filter clogging has been carried out by the industry. The conclusions reached to date indicate that the problem of fuel filter clogging will only be encountered when certain jet or kerosine type fuels are used. The composition of the fuels tends to play an important part in this as illustrated in Fig. 1. This figure indicates a wide difference in the filter clogging tendencies between three different fuels, all of which meet a −76 F freeze point by the ASTM method. This illustrates the inadequacy of the present standard method of protecting the user from filter clogging difficulties. There apparently is no reliable test for the filterability factor of fuels available at present; however, I feel confident that when we can identify the hydrocarbon components that cause filter clogging troubles, they can be ruled out of turbine fuels by a physical bench test requirement in the specification.

One question that has arisen many times with the use of heavier types of fuels has been the ability to restart the engine. Fig. 2 indicates the per cent increase in fuel flow required to begin with the heavier fuels and although a larger fuel flow is required to start a kerosine fuel than an aviation gasoline, the problem loses significance if satisfactory starts can be made on all fuels to the lowest temperature required. It is extremely difficult to compare fuels as to their starting characteristics except with a constant configuration of burner, ignition system and operating conditions. The ability of an engine to restart in flight depends to a great extent on the compressor characteristics. Restarting or lighting is more difficult with high air velocities in the burner and low pressures. Therefore, some airplanes can best be restarted by slowing the forward speed or reducing the ram pressure and thus slowing the velocity through the burner, whereas other can be restarted

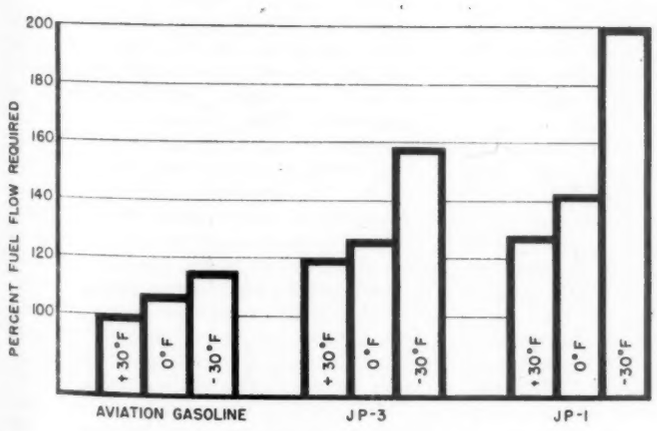


FIG. 2. Effect of volatility on restarting.

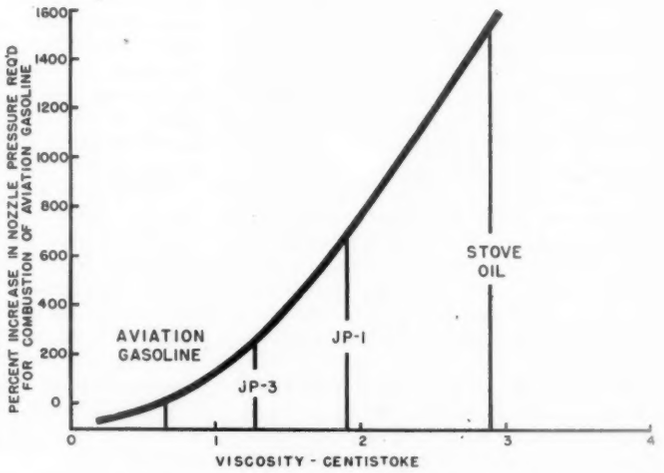


FIG. 3. Effect of viscosity on usable nozzle spray.

easiest by diving them to obtain the maximum amount of ram and increasing the pressure in the burner in relation to the velocity through the burner. Which of these two approaches is used depends on the compressor design, the burner design and the altitude at which the airplane is operating. Other things which play an extremely important part in the starting of a turbine engine are its ignition system, how well the burners drain excess fuel so as not to get hot starts, and the location of the nozzle with respect to the spark plugs. It is, therefore, hard to draw concrete conclusions other than the one already presented, i.e., that the heavier fuels are harder to start than the more volatile fuels, but by good engine design they can be started under all conditions required.

Primarily, complete rapid combustion requires a perfect mixture of fuel and air in the stoichiometric fuel/air ratio. This necessitates the best obtainable atomization of the fuel, although there is not sufficient time for this since the fuel must be uniformly distributed throughout the combustion space. This condition probably cannot be realized without the action of gas currents and turbulence and the resultant performance penalties. Even if it were possible for mixing of the fuel and air to take place while the fuel was in a liquid state, the rapid combustion required in the turbine burner can take place only after the fuel is evaporated. A low boiling point fuel and high air temperature favor evaporation as does high air density because of the high heat capacity of the air. The desirability of fine atomization can be realized from the fact that the rate of heat absorption of the fuel is directly proportional to its surface area or the fuel droplet diameter squared and the rate of temperature rise is inversely proportional to its volume or the droplet diameter cubed. Actually, in order to provide good combustion over wide fuel/air ratio limits, it is necessary that the drops vary in size as the fuel/air concentration changes in the burner. With proper variation in fuel drop size, the flame zone is extended so that wide engine fuel/air ratio limits can be obtained.

A definite restriction that is counter to wide fuel flow range accomplishment is the fuel pump pressure limitations. In the medium and high pressure turbo machines, the maximum compressor discharge pressure will be from 100 to 200 psi. If it is assumed that a 100 psi pressure drop is necesssary for the fuel metering device, and that 500 psi fuel pressure is available only 200 to 300 psi fuel pressure drop can be utilized for atomization. This problem would be materially easier if the pumps could operate at higher pressures and allow higher nozzle pressure drop. Operating the pumps at higher pressure, however, is a matter of metallurgy and lubrication. So far the metals are just not available that will operate at high pressures without adequate lubrication. A single turbine fuel would greatly aid the problem of coordinating the pump, nozzles and burners. Fuel viscosity and density both have a considerable effect on nozzle performance, especially when they are permitted to vary over a wide range. The most important fuel properties influencing nozzle performance are drop size, flow range, and spray angle. Fuel density changes affect fuel flow. Surface tension is probably a relatively minor consideration since nozzle design can reduce its effect. The effect of fuel density by itself on nozzle performance is probably only to increase flow at a given pressure. The effect of density on fuel flow can be shown to be proportional to square root of the density change.

While it is easy to demonstrate that heavier fuels are cheaper and more readily available, there is a limit to the advantage to be gained from considering a fuel of too heavy a viscosity. Fig. 3 indicates the increase in nozzle pressure required over aviation gasoline to maintain a usable nozzle spray. This shows that tremendous pressures are required for conventional nozzles for heavy fuels and fuels such as Bunker "C" having approximately 92 C. S. at 60 F would be way beyond the pressures that we are now capable of handling. Of course, such schemes as preheating of the Bunker "C" is the process presently used in boiler plants, but this much machinery would be making flying refineries out of our aircraft.

There have been several examples of fuels in service operation that have made operation inefficient and dangerous. A recent situation occurred at a military operating activity using JP-4 fuel. After flights totalling 4 to 7 hr, the fuel nozzle and ignitors were so covered with carbon that if an engine had experienced a flameout in flight, it would have been impossible to relight it and would result in one less fighter airplane for our defense needs. The condition is shown in Fig. 4 and Fig. 5. After about 30 hr of flight, deposits in the burners had grown to condition shown in Fig. 6 and resulted in severe burner buckling as shown in Fig. 7. This severe condition occurred when the activity started to use a batch of JP-4 containing over 9 per cent of the fuel as aromatics boiling over 400 F. This crippling situation was eliminated and operation returned to normal by making a corrective change in the fuel.

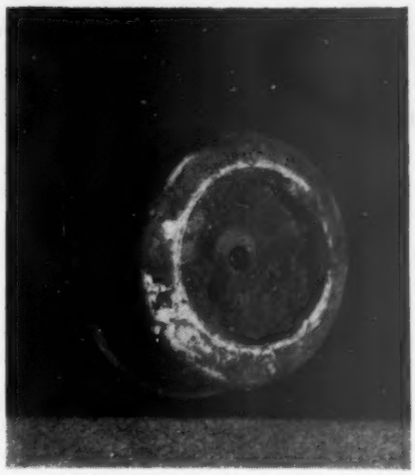


FIG. 4. Carbon deposits on fuel nozzle after about 7 hr operation on JP-4 fuel containing 9.2 per cent high boiling (above 400 F) aromatics.

FIG. 5. Carbon deposits on igniter after about 7 hr operation on JP-4 fuel containing 9.2 per cent high boiling (above 400 F) aromatics.

FIG. 6. Carbon tumor in combustor after 30 hr operation on JP-4 fuel containing 9.2 per cent high boiling (above 400 F) aromatics.

FIG. 7. Combustor after 30 hr operation on JP-4 fuel containing 9.2 per cent high boiling (above 400 F) aromatics. Note buckling resulting from carbon deposits.

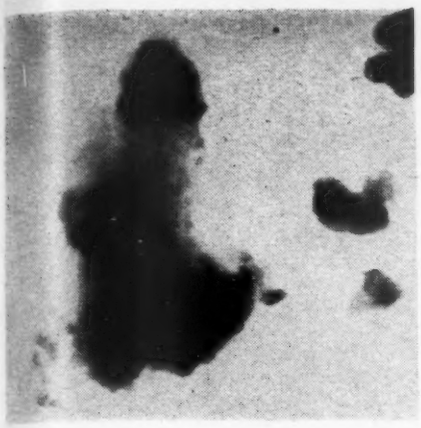
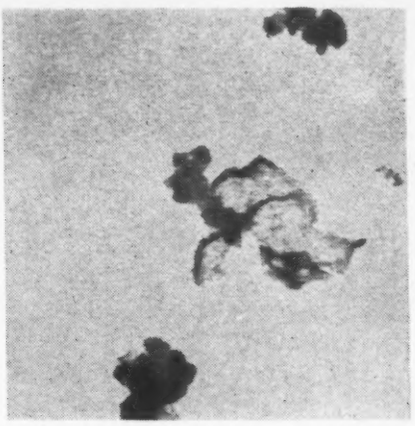


FIG. 8. Example of amorphous carbon photographed through an electron microscope at 27,000 magnification. Note fluffy indistinct boundary.



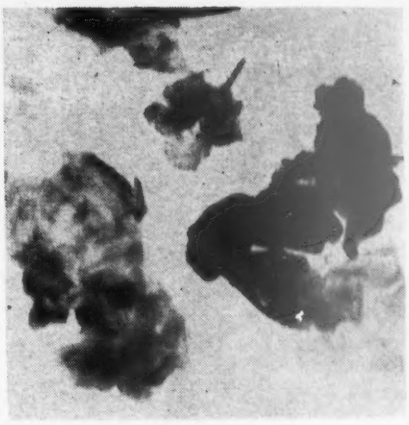


FIG. 9. Carbon deposits from a late model engine photographed through an electron microscope at 27,000 magnification. Note the sharp edges which indicates this is graphitic carbon.

It should be made very clear that only a small percentage of the total jet fuel produced causes this severe condition and, therefore, it comes to light only infrequently. If it occurred at a critical time and place in our defense program, however, the result could be extremely serious.

Some people have the philosophy that the responsibility of making the jet engine burn clean lies with the engine designer alone. I would like to challenge that philosophy and show reasons why. The engine designers certainly share in the responsibility, but also they have done something about it. It is known that carbon, when properly examined, can be classified according to its structure. Further, it is known that from a study of the crystalline structure of the carbon, it is possible to determine something about how the carbon was formed. Therefore, it is possible to determine whether or not carbon in a burner was caused by a design limitation or by an inherent property in the fuel. Designers have struggled with this problem for some time. Esso Standard Oil Company cooperated with Pratt & Whitney Aircraft Division in a carbon analysis program, using the technique and facilities of the Esso Laboratories to determine the type of carbon produced in jet engines. One type of carbon is shown in Fig 8 at 27,000 X; the amorphous which is formed with an excess of oxygen at low pressures and temperatures. Fig. 9 at 27,000 X shows a sample of carbon removed from a late design jet engine and since it is the graphitic type, which is pure carbon and not artificially made by poor fuel/air condition, it was not formed because of lack in design. The designer then has succeeded in fulfilling his responsibility. The only avenue left for him to pursue is to try to arrange it so the carbon which is inherent in the fuel will be formed in the exhaust stream as smoke instead of as lumps in the engine. Whether or not he is successful in this really makes little difference since it would only shift the problem from an engine reliability problem to an extremely serious combat hazard.

Turbine fuels thus far used in full scale engines have demonstrated varying degrees of carbon deposition. Some fuels meeting requirements of present specifications have produced severe carbon deposition. Experience gained during early tests on the original referee fuel to the JP-3 specification in several engine models demonstrated the severe coking tendencies of this fuel. To aid in establishing the extent to which the fuel was responsible for the coking, several experimental fuels were obtained and compared under identical conditions. Fig. 10 shows the wide range of coking tendencies between aviation and diesel fuel. In an effort to discover what offending components of the individual fuel might be contributing to the large differences, a series of fuels was made up with only one component varied. The aromatic content of the fuel was held constant, but the boiling range of the aromatics was changed. As seen in Fig. 11, there is a definite trend, greater carbon deposition with heavier boiling aromatics. Since these fuels with the same total (by volume) aromatic content demonstrate such a wide tendency for carbon formation, it is apparent that the total (by volume) aromatic content in itself is not significant. To establish what was a satisfactory level of carbon deposition, considerable service experience has been obtained on one fuel and it proved to be reasonably satisfactory. This fuel had the end boiling point of the aromatic component limited to 400 F. The average aromatic boiling point of this component was slightly less than this.

The above discussion indicates that volatility of the fuel is not the important thing in regard to carbon deposition, but it is the chemical composition of the fuel itself. While it is the ultimate goal to be

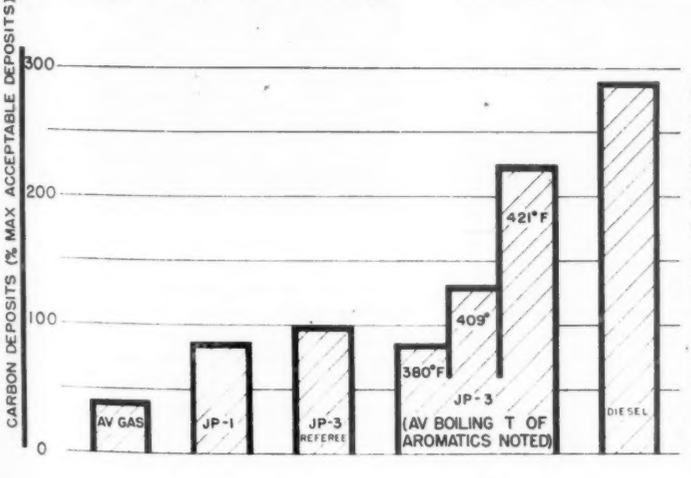


FIG. 10. Coking tendencies of jet fuels.

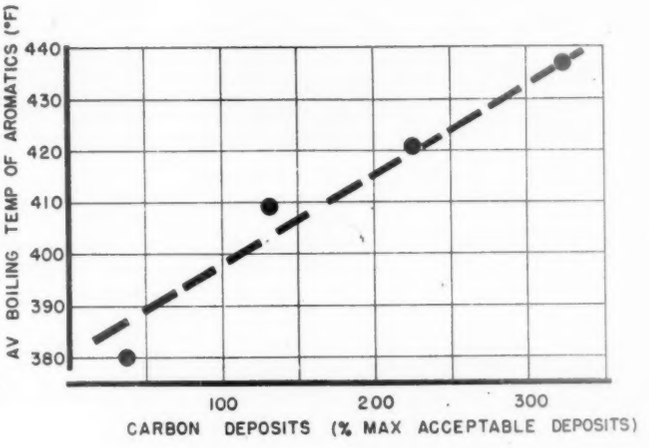
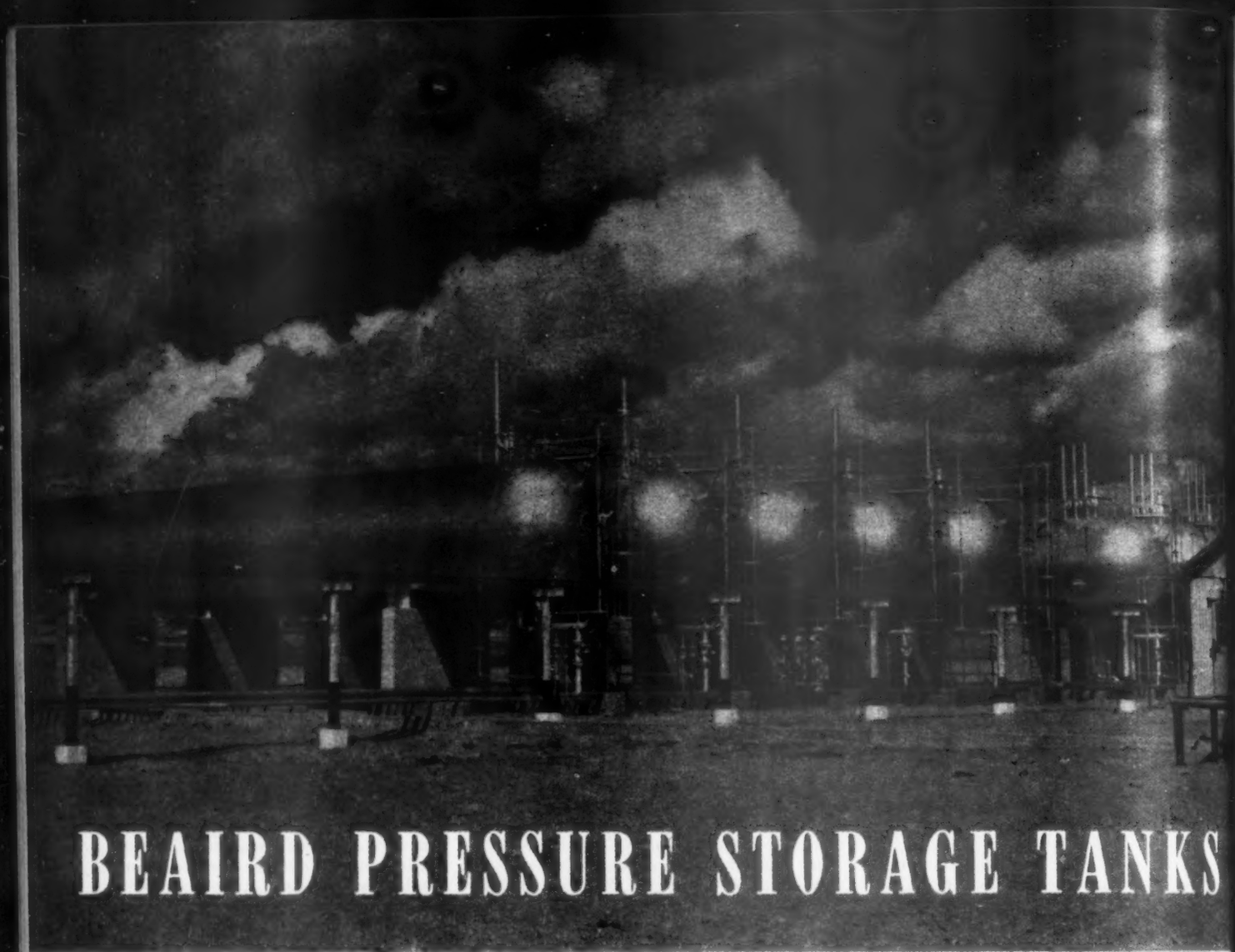


FIG. 11. Aromatic boiling range vs carbon deposition.



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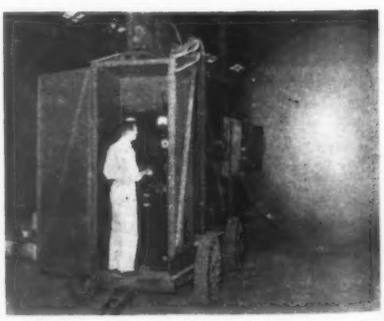

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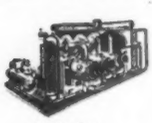

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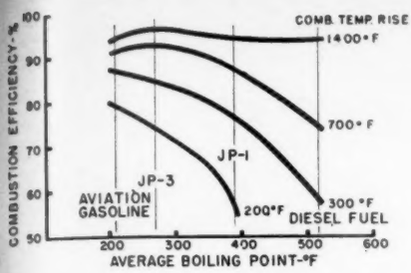


FIG. 12. Effect of volatility on performance — optimum nozzle size for JP-3 fuel.

able to burn anything, the practical significance that the chemical composition will have to be held within reason. As we learn more about the art of matching turbine fuels and burner requirements, it will become more obvious which one of the components is more desirable.

Fig. 12 indicates the effect of volatility on performance. This figure illustrates that approximately the same combustion efficiency can be obtained from fuels ranging from aviation gasoline to diesel fuel at the higher combustion temperature rises of the burner. At lower temperature rises in the burner, the fuels show marked differences. This might be expected because, as previously explained, fuels do not burn in the liquid state. These data were obtained with a nozzle which is more or less optimum for the JP-3 fuel and a burner that has been developed around JP-3. A change in nozzle size would improve the heavier fuels, but will not necessarily make their combustion efficiency at the lower combustion temperature rise equivalent to that of the more volatile fuel. A different burner with a charge in the primary to secondary air ratio would also shift the curve. The point most significant in this illustration, however, is that if the nozzle and burner are selected for a particular fuel, it will not give equivalent performance on a different fuel.

In conclusion we can say that most of the fuel produced, perhaps 95 per cent, is suitable for engine use. The remaining small percentage is unusuable and makes performance unreliable and dangerous. Therefore, in order to have an Air Force second to none, aid of the petroleum industry is strongly solicited to expand their efforts in the direction of making a suitable jet fuel, which is needed by all engine manufacturers, and if it is not sufficiently available, put in the necessary plant facilities to satisfy the need. * * *

Jet Fuel for Civil Aircraft

J. BENNETT HILL*

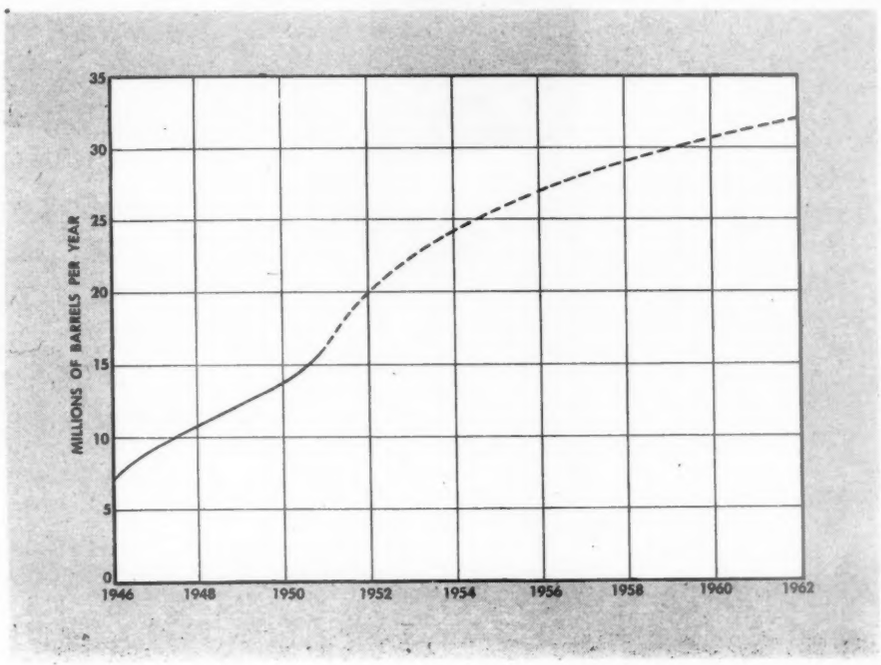
THE question as to whether the commercial airliner of the future will be turbine-powered can be answered only "yes." Aside from the public's increased demand for speed and the glamour of jet-propelled aircraft, there is a still more realistic reason for this answer. The development of any new engine of the size to power these planes is at enormous cost. There is not a large enough demand for these engines for commercial use to make such development attractive to the builders, and the trend, therefore, has been to purchase or adapt engines which have been developed for military purposes. The military trend in these large engines is wholly toward turbine engines and, in fact, development of large reciprocating engines has practically stopped. If, therefore, we are to have further developments in commercial airliners, as of course we will, it will in all probability be via the turbine engine. For smaller craft piston engines will be made and used for a much longer time, although even here there is an interest experimentally in turbine engines.

The argument is still on as to whether turbine engines of the next 10 years will be turboprop or turbojet. Five years ago there was a rather general feeling that the turboprop would come first and possibly later the turbojet. In 1947, Gregory and Pomeroy made a valuable contribution to the thinking at the time by getting together a large number of opinions as to the changes in aircraft engine powerplants, and came up with the average opinion that by 1952 12 per cent of the transport planes would be powered by turboprop and 3 per cent by turbojet, and that by 1957 41 per cent would be turboprop and 14 per cent turbojet. The 1952 prediction has been by no means realized as there are no commercial turbine-powered planes flying yet in this country. The British are ahead of us, but their turbine-powered aircraft in actual commercial service are at present limited to a half-dozen deHavilland Comets powered, by the way, by straight jet engines. These planes have cut the flying time from London to Johannesburg from about 28 hr to about 17 hr. Within the next few months the British expect to put into service the turboprop Vickers Viscount, of which they have about 50 on order. The turboprop Bristol Brittania will be put in transatlantic service in 1954. Both turbojets and turboprops are being discussed by the airlines in the U. S., and both will probably be used. The turbojet in airline thinking seems to be catching up on the turboprop.

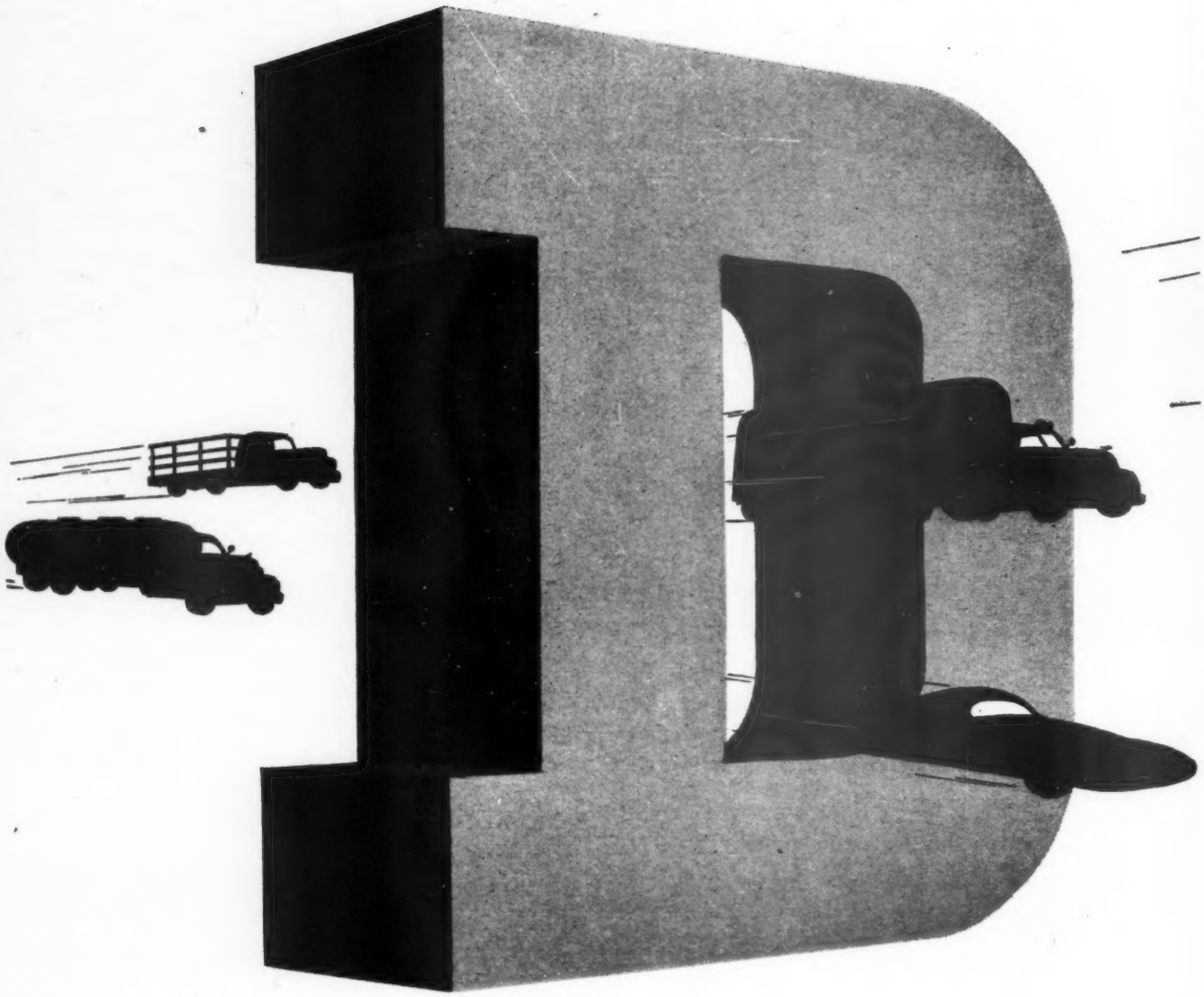
As both types of turbine engines will require about the same fuel, the question as to which comes first is of not much more than academic interest for the petroleum industry. The question for us is how much and when. For these predictions your crystal ball is almost as good as mine, but a little figuring may at least point out the order of magnitude which we may expect.

The total commercial use of aviation gasoline in the U. S. has grown from

FIG. 1. Commercial aviation gasoline consumption by years.



*Sun Oil Company, Marcus Hook, Pennsylvania.



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7,000,000 bbl in the first post war year of 1946, to 16,000,000 bbl in 1951, and an estimated 20,000,000 bbl in 1952. The curve (Fig. 1) shows a fairly consistent rate of climb up to 1950, but an accelerated rate of climb in the last two years. The demand for fast travel is definitely on the up. If we were to extrapolate this curve on the assumption that reciprocating engines would still power our aircraft, we might arrive at a figure of 28,000,000 bbl in 1957, and 32,000,000 bbl in 1962.

The use of turbine-powered air transports by the airlines in this country will probably not be of any importance quantitatively in 1957. The problems of the airlines in making the shift are many. Even if they should decide to purchase already developed British planes, it is reported that the British manufacturers already have orders to carry them through 1954. After planes are delivered the airlines will still have the problems of setting up operating and maintenance procedures, of integrating the faster planes into the traffic pattern of slower planes, and many others. There will, of course, be British and other foreign planes fueling in this country, but even at that an outside estimate of the amount of jet fuel might be 4 per cent of the total aviation fuel.

For 1962 the opinions of the experts on probable jet fuel consumption vary from 5 to 20 per cent of the avgas demand. Let us take 15 per cent as a fair estimate.

We, therefore, arrive at a jet fuel demand of 1,100,000 bbl in 1957 and 4,800,000 bbl in 1962. Conservative estimates of our crude production in these two years are 2.6 billion barrels in 1957, and 2.8 billion barrels in 1962. The jet fuel demand would therefore be 0.04 per cent of our crude in 1957, and 0.17 per cent in 1962.

As compared with these figures, the railroad diesel fuel consumption in 1951 was 57,000,000 bbl. Kerosine was 131,000,000 bbl. Motor gasoline was close to one billion barrels. We are, therefore, dealing with figures which are certainly not too large for the petroleum industry to handle, and are not anything we should be frightened about, although we should certainly take them into consideration in our future plans.

The next obvious question is what quality fuel will be required for commercial turbine aircraft. There is practically universal agreement that it will not be the same as the military fuel, as, for example, JP-4. The extent of the safety advantage of a high flash fuel is still disputed, but probably everyone will agree that there is enough advantage to make the airlines insist on a low volatility fuel of the kerosine type. We may expect something, therefore, similar to JP-1. For stability reasons it may be a straight-run fuel, and for combustion reasons it may be limited by excluding those crude sources which would give a very high aromatic content. On the other hand, there would seem to be no reason that commercial fuel should have the very low freezing point of -76 F required for military fuels. This specification might very well come up to —40. The present British commercial specification is probably not very far from what will be adopted. Typical British specifications are as follows:

Gravity, specific	0.79—0.83
(API, approx.	39—48)
Heat of combustion	18,500 Btu/lb
Freezing point, max.	—40 C (—40 F)
Flash point, min.	38 C (100 F)
Aromatics, max by volume	20 per cent
Sulfur, max by weight	0.2 per cent
Kinematic viscosity at 0 F, max.	6 cs.

How fast the utilization of turbine engines by the airlines will grow will depend on the cost of the fuel to them. The cost will probably be of the order of kerosine or slightly above. It will probably find its level about 1 to 1.5 cents under regular grade motor gasoline. It should be materially below any of the present grades of aviation gasoline. As compared with current Gulf Coast prices of about 10 cents for kerosine, 11.5 cents for regular grade motor gasoline, and 16.5 cents for Grade 100/130 aviation gasoline, the corresponding figure for jet fuel for commercial transports should be between 10 and 12 cents per gallon at the current prices, and probably closer to 10 cents. This is provided, of course, that airlines do not hang on too many fancy specifications.

The day of jet fuel for commercial aircraft is coming, but not so fast or in such volume that the petroleum industry cannot take it in its stride. ★ ★ ★

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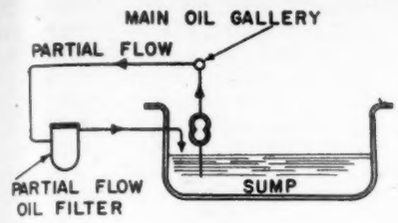
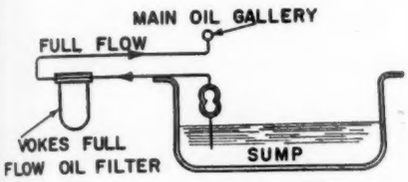
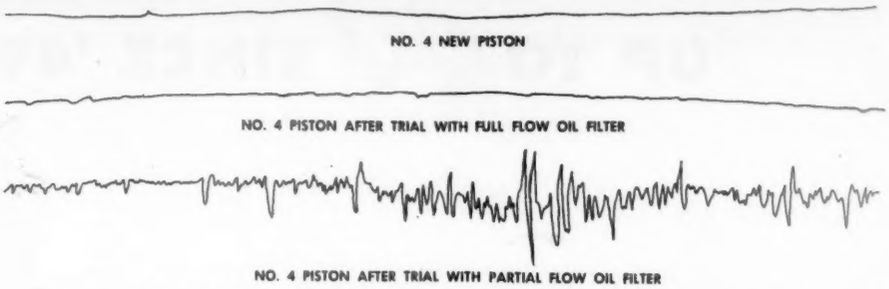


Flow arrangement for first trial with full flow of oil filter.



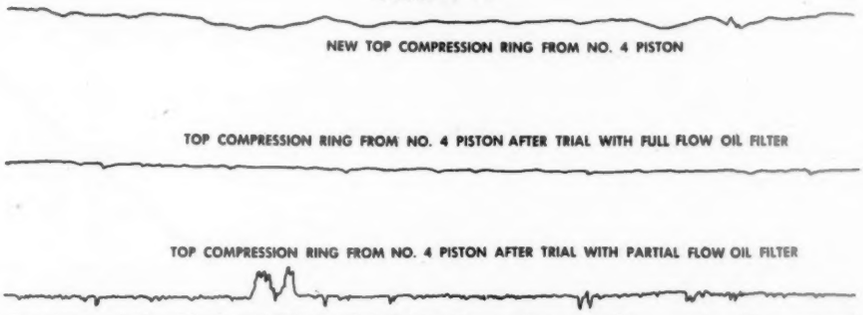
Flow arrangement for second trial with partial flow oil filter.

DIAGRAM 19.



Tracings of the National Physical Laboratory surface profile graphs. The records were taken in a circumferential direction below the scraper ring groove, on the thrust side of the piston. All magnifications are the same and the surfaces recorded are similarly positioned on each piston.

GRAPH 7.


NEW TOP COMPRESSION RING FROM NO. 4 PISTON
TOP COMPRESSION RING FROM NO. 4 PISTON AFTER TRIAL WITH FULL FLOW OIL FILTER
TOP COMPRESSION RING FROM NO. 4 PISTON AFTER TRIAL WITH PARTIAL FLOW OIL FILTER

Tracings of the National Physical Laboratory surface profile graphs. The records were taken in a circumferential direction. All magnifications are the same and the surfaces recorded are similarly positioned on each piston ring.

GRAPH 8.

Maintenance of Internal Combustion Engines — Filtration of Air and Oil*

Full-flow filtration of air and oil gives much more complete protection from wear than does partial-flow filtration

PHILIP H. MOORE

THE first article in this series† described filtration experiments on a conventional British gasoline engine, the second article described similar experiments using a compression ignition engine. The following and final article describes tests on the same gasoline engine as used at the beginning of these researches, but the experiments are of a different nature.

The object of these tests was to examine the respective merits of full-flow and by-pass filtration. Much discussion has taken place as to whether all or part of the oil stream should be filtered, and it is hoped that the following information will stimulate thought on this subject as well as contribute factual data.

Dust Atmosphere

The dust atmosphere was created by feeding an artificial dust into the air intake stream, as in the first series of trials (June, 1950, issue of the Petroleum Engineer).

The dust was fed into the air intake at a continuous rate of 0.236 gm per 1000 cu ft of air. The dust was made from silica to the following size distribution:

90.4 per cent by weight 53-20 microns
5.1 per cent by weight 20-10 microns
2.0 per cent by weight 10-5 microns
2.5 per cent by weight 5-0 microns

EXCLUSIVE

Equipment

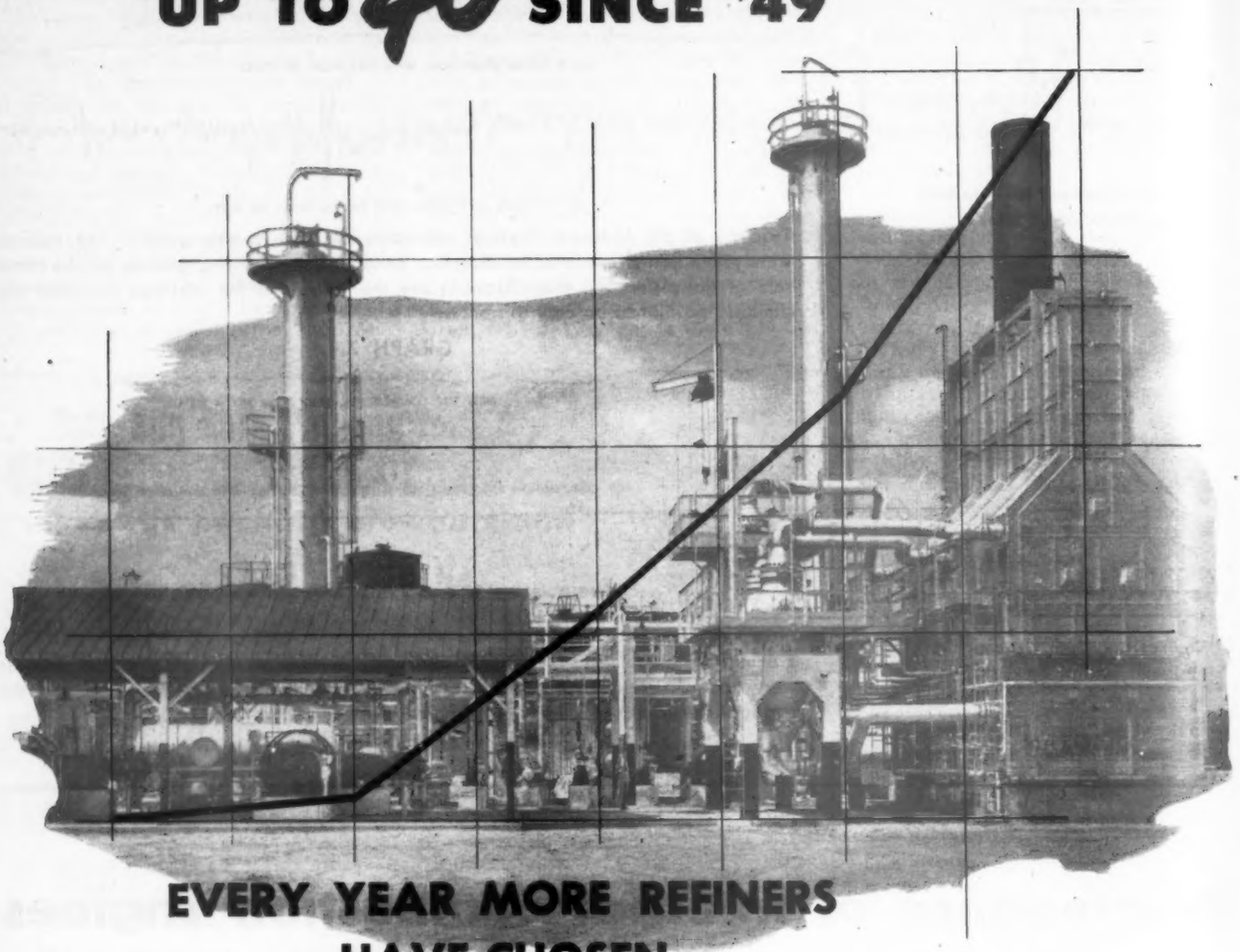
The equipment used for these experiments was illustrated in Fig. 1 of the first article in this series. The power unit was a four-cylinder side valve, four-stroke gasoline engine. Its bore was 57 mm (2.24 in.) and stroke 100 mm (3.94 in.). The engine lubrication system consisted of a 45 psig feed from a gear pump to the crankshaft bearings. The little end bearings and valve mechanism were lubricated by splash.

In the first article, Diagram 1 shows the Vokes air filter that was used for the trials, and Diagram 3 shows the Vokes full flow oil filter, the latter of which was used for the full-flow experiments. The by-pass oil filter was of a well-known proprietary make. It was not altered in any way and was fitted to the en-

*A research sponsored by the Vokes Filter Company, England. The author is indebted to Vokes Ltd. for permission to publish this article.

†"Maintenance of Internal Combustion Engines—Filtration of Air and Oil," by Philip H. Moore, The Petroleum Engineer, June, 1950, p. C-7.

UP TO 40 SINCE '49



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gine according to the manufacturer's recommendations. Diagram 2 illustrated the assembly used for feeding the dust into the air filter intake. The dust feed apparatus allowed a continuous supply down to half a gram per hour by employing a hopper and electrically vibrated chute. The feed rate was controlled by adjusting the angle of the chute. Diagram 19 shows the oil flow arrangement for the full flow and partial flow filters respectively.

Standardization of Engine

For a true comparison all wearable parts of the engine must be uniform before each test. This was accomplished by obtaining standardized stocks of liners, piston assemblies, bearing shells, crankshafts, valves, and valve guides and inserting a new set of components before commencing each individual test. The liners were inserted into the block and then bored out to the diameter which was the same for both experiments.

Prior to each test, engine variables such as ignition adjustments, valve and bearing clearances were made to conform to those figures recommended by the engine manufacturer.

Fuel and Lubricating Oil

The same fuel and lubricating oil was used for both tests, complete details of which were given in the first article of this series. The oil did not contain additives and a standardized procedure was adopted for measuring and topping up.

The center main bearing shells and No. 4 piston assembly were chosen arbitrarily for comparison purposes; the others showed little variation.

Operating Conditions

For each trial the running-in period consisted of six hours at ¼ full load, 1750 rpm and six hours at ½ full load, 2000 rpm. The engine was then run for 45 hr at ¾ full load, 2500 rpm to complete the test.

Sump oil temperatures were controlled at 69 ± 3 C (156.2 ± 5.4 F) by means of a water-cooled coil.

Inlet and outlet coolant temperatures were regulated to 30-35 C (86-95 F) and 78-82 C (172.5 — 180 F) respectively.

Test Procedure

Before assembling the power unit, surface profile graphs were taken of the piston top land and the top compression ring from No. 4 piston. The surface of the center main bearing shells and the No. 4 big end bearing shells also were recorded. The No. 4 piston ring assembly, center main and No. 4 big end bearing shells were photographed.

The engine was assembled, filled with oil and connected to the other components of the test plant.

After the running-in period, the engine's performance was checked by taking a power curve. If the results were satisfactory then the trial proper was commenced.

At the end of each trial, surface profile graphs were again taken of the same

Tracings of the National Physical Laboratory surface profile graphs. All magnifications are the same and the surfaces recorded are similarly positioned in each case shown below.

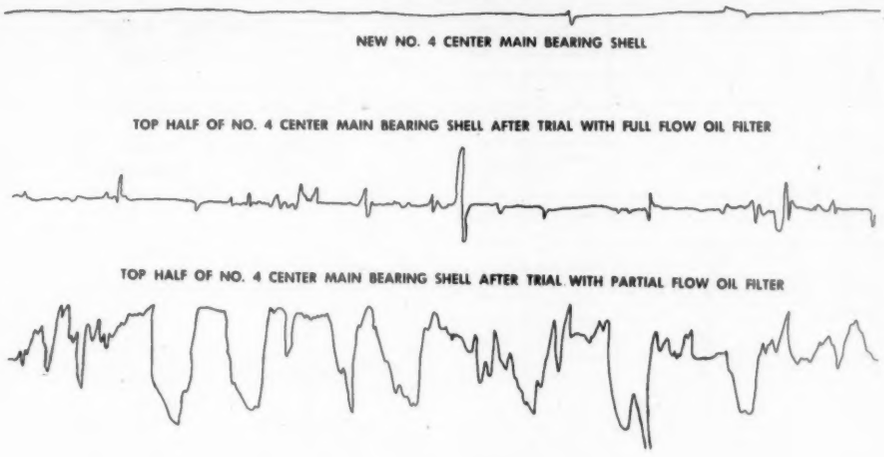
NEW NO. 4 CENTER MAIN BEARING SHELL
TOP HALF OF NO. 4 CENTER MAIN BEARING SHELL AFTER TRIAL WITH FULL FLOW OIL FILTER
TOP HALF OF NO. 4 CENTER MAIN BEARING SHELL AFTER TRIAL WITH PARTIAL FLOW OIL FILTER

DIAGRAM 9.

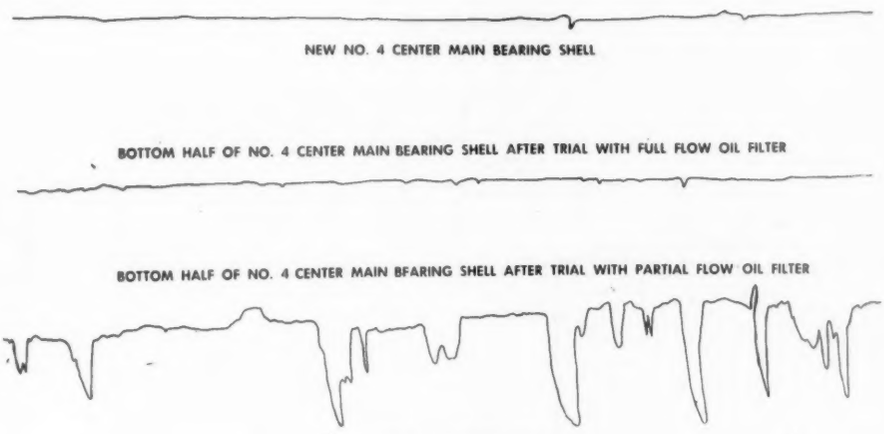
NEW NO. 4 CENTER MAIN BEARING SHELL
BOTTOM HALF OF NO. 4 CENTER MAIN BEARING SHELL AFTER TRIAL WITH FULL FLOW OIL FILTER
BOTTOM HALF OF NO. 4 CENTER MAIN BEARING SHELL AFTER TRIAL WITH PARTIAL FLOW OIL FILTER

DIAGRAM 10

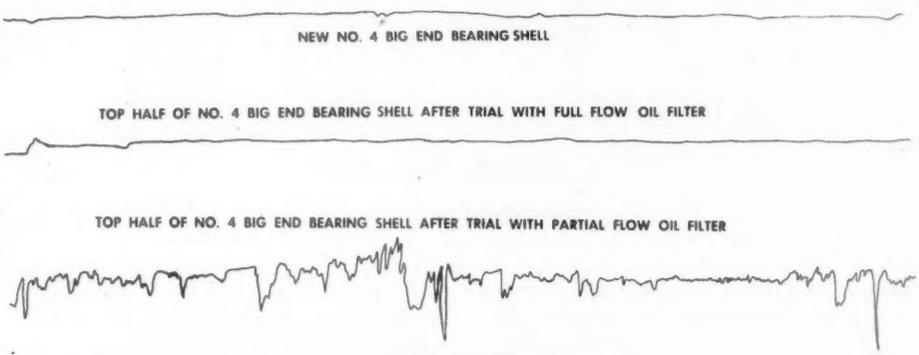
NEW NO. 4 BIG END BEARING SHELL
TOP HALF OF NO. 4 BIG END BEARING SHELL AFTER TRIAL WITH FULL FLOW OIL FILTER
TOP HALF OF NO. 4 BIG END BEARING SHELL AFTER TRIAL WITH PARTIAL FLOW OIL FILTER

DIAGRAM 11.

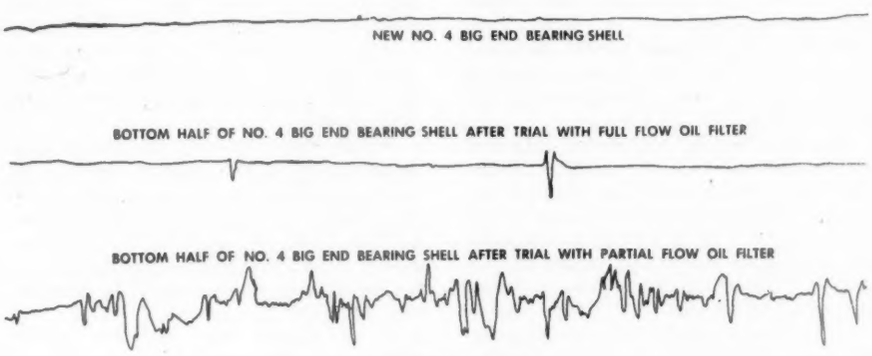
NEW NO. 4 BIG END BEARING SHELL
BOTTOM HALF OF NO. 4 BIG END BEARING SHELL AFTER TRIAL WITH FULL FLOW OIL FILTER
BOTTOM HALF OF NO. 4 BIG END BEARING SHELL AFTER TRIAL WITH PARTIAL FLOW OIL FILTER

DIAGRAM 12.

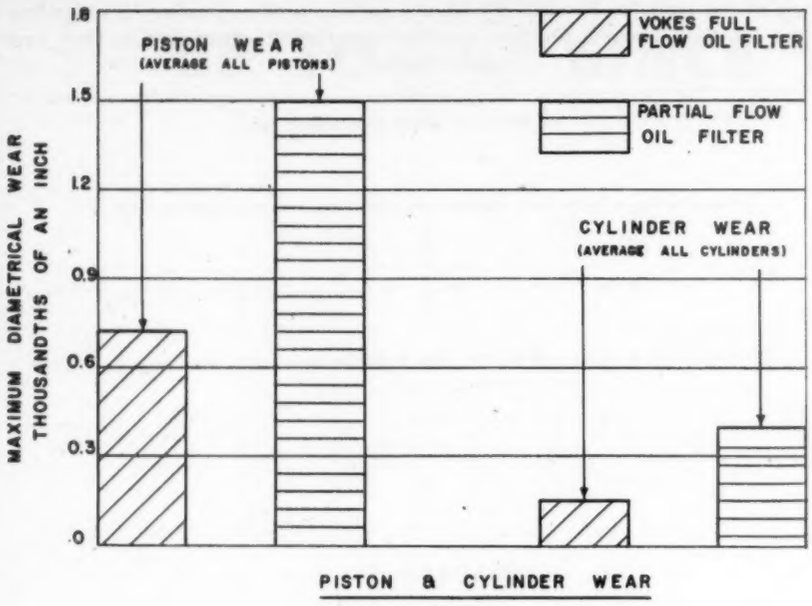

DIAGRAM 20.

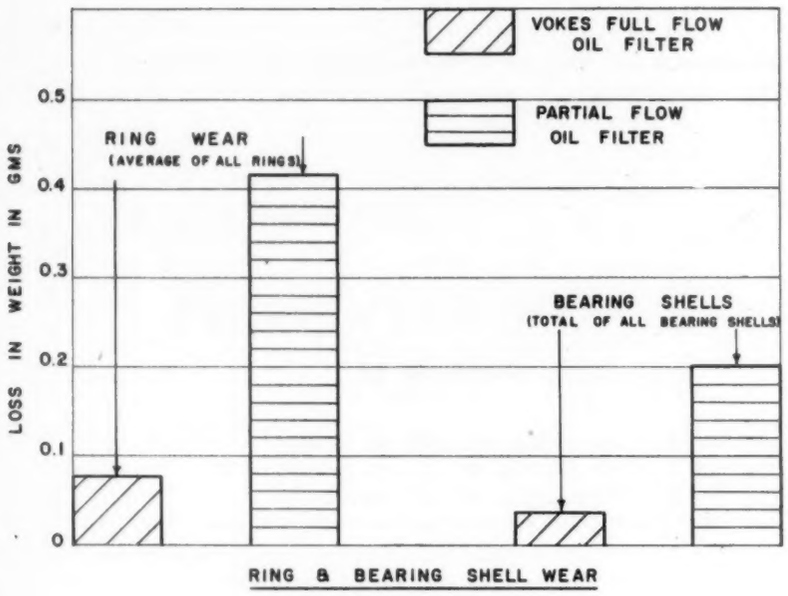

DIAGRAM 21.

components whose surfaces were recorded before assembling the engine. All other wearable components were either weighed or measured. The used No. 4 piston and ring assembly, center main and No. 4 big end bearing shells were again photographed.

Piston crown deposits were weighed and analyzed. The used oil was examined in the laboratory and a photomicrograph taken to show its appearance.

The same test procedure was adopted for the second trial in order to maintain comparative conditions. The air filter was fitted with a new element before each test. At the end of the experiments an exhaustive study was made of the matter retained on the elements of the two different filters.

Piston and Cylinder Wear. Diagram 20 shows the relative piston and cylinder wear, based on maximum reduction in diameter. The saving in wear using the full flow filter can be seen to be considerable.

Ring and Bearing Shell Wear. Diagram 21 shows the relative ring and bearing shell wear. These figures are more reliable than piston and cylinder linear measurements of maximum bore diameter, since they are based on loss in weight which can be more accurately determined.

Valve Stem and Guide Wear. Diagram 22 shows the relative valve stem wear based on maximum reduction in diameter. The relative valve guide wear is based on loss in weight measurements. The valve guide wear should not be considered very accurate because of the difficulty in removing the guides from the engine block without tearing away some of the metal.

Crankshaft Journal Wear. Diagram 23 shows the relative main and big end journal wear. These results show very clearly the importance of full-flow oil filtration.

Combustion Chamber Deposits. Table 3 gives the quantity and analysis of the combustion chamber deposits from both trials. The deposits are similar except for the per cent silica content which is much higher when using the partial flow filter.

Condition of Used Oil

Table 4 gives the properties of the new and used lubricating oils. It can be seen that the amount of insolubles remaining in the oil is less when using the full-flow filter.

There is more crankcase dilution using the partial-flow filter. This is probably caused by greater cylinder assembly wear which decreases the efficiency of the seal between the combustion chamber and the crankcase. The used oil from the full-flow trial shows more acidity.

Microscopical Examination of Used Oils

Figs. 17 and 18 both show high magnified photographs (x 250) of the used oil from both experiments. From Fig. 18 it can be seen that filtering a portion of the oil does not insure against the possibility of some very harmful particles being present for the duration of the run. It can, however, be seen that the by-pass filter removes more of the smaller size particles. In other words the by-pass filter gives a finer degree of filtration but because only a portion of the oil goes through the element some large particles escape collection and the result is appreciable engine wear. This means that within these limits it is better to filter all the oil all the time rather than filter part of the oil all the time even though the partial filtration method removes some very small particles which are not collected by the full-flow filter.

TABLE 4. New and used oil analysis.

Property	New oil	Used oil from full-flow trial	Used oil from by-pass trial
Sp. gr. at 60 F	0.897	0.895	0.895
Redwood viscosity at:			
70 F	1565	1410	1170
140 F	185	168	155
200 F	65	63	61
Closed flash point F	405	210	192
Per cent benzene insolubles		Less than 0.01	0.14
Per cent petroleum ether insolubles		0.03	0.14
Ash per cent of benzene insolubles		Quantity of benzene insolubles too small for accurate determination.	38.8
Acidity mg KOH/gram		0.32	0.16

TABLE 3. Combustion chamber deposits.

	With full-flow filter	With partial-flow filter
Total weight, grams	1.59	1.72
Per cent oil and asphaltic matter	9.92	4.16
Per cent carbon (loss on ignition, not including oil and asphalt)	35.35	40.58
Per cent silica	2.50	17.23
Per cent metals as oxide	52.23	38.03

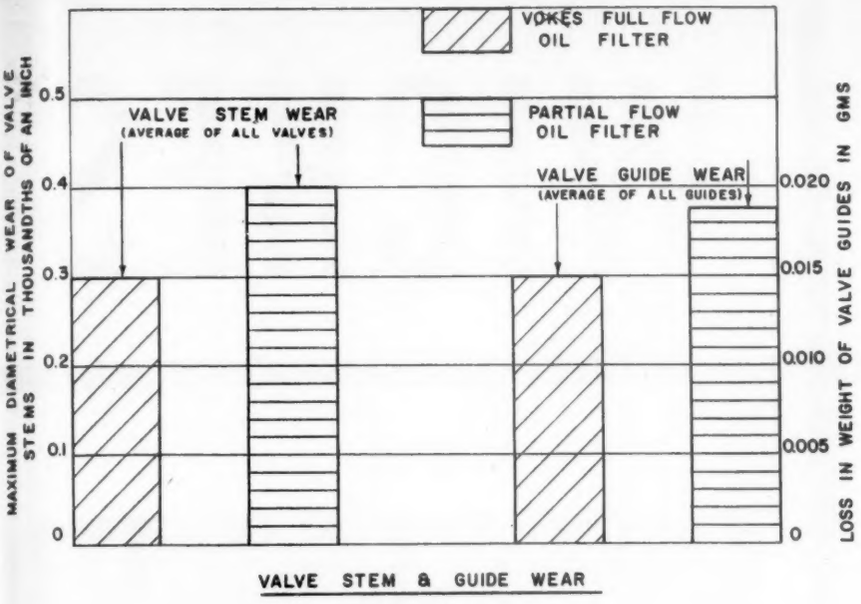

DIAGRAM 22.

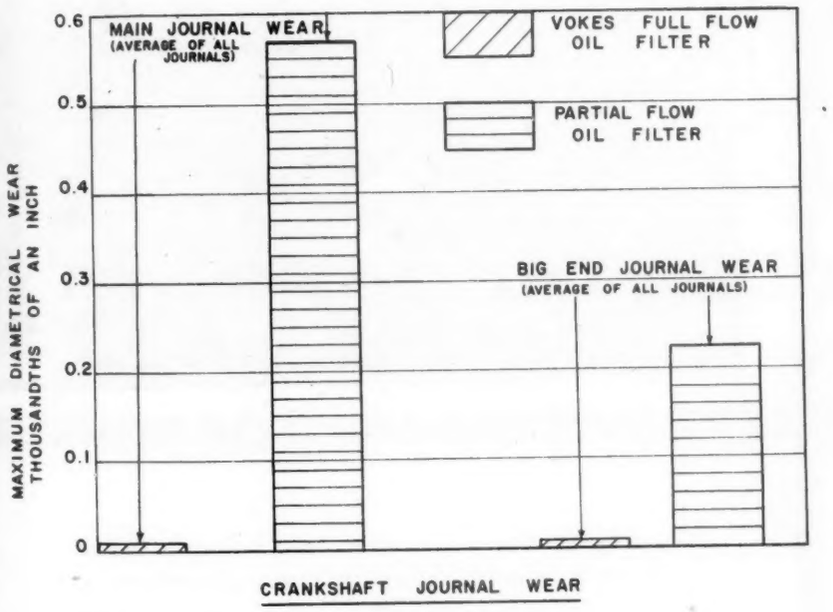

DIAGRAM 23.

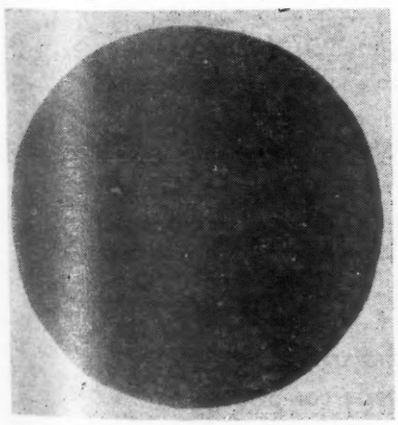

FIG. 17. Photomicrograph of used lubricating oil from the first trial with full flow oil filter in circuit.

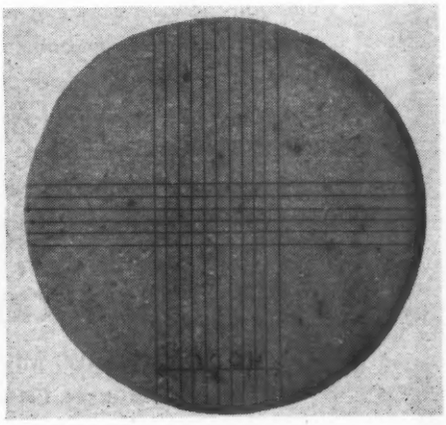

FIG. 18. Photomicrograph of used lubricating oil from the second trial with partial flow oil filter in circuit.

Condition of Engine Surfaces

Graphs 7 to 12 show highly magnified surface contours of the engine's piston, No. 4 top compression ring, No. 4 center main bearing shells and No. 4 big end bearing shells, at the end of each trial. These contours show that a superior surface results when using the full-flow filter.

Examination of Used Oil Filters

At the end of the experiments both filters were opened up and all solids removed by washing with petroleum spirit. Each deposit was then filtered through a ceramic thimble and subsequently examined. The following information was obtained:

	Full-flow filter	By-pass filter
Total weight of solids obtained in filter element, gm	7.77	28.18
Percentage of combustible solids	63.7	47.83
Percentage of non-combustible solids	36.3	52.17
Maximum particle dimension microns	98	68
Dimensions in microns of some of the larger particles were as follows:		
Quartz	98 by 41	20 by 18
	95 by 32	17 by 13
	82 by 49	12½ by 10
Metal Oxides	74 by 72	68 by 55
	66 by 62	62 by 37
Carbon	75 by 70	45 by 35
	54 by 52	40 by 32

When considering the above results it should be noted that the factors affecting these results are: (1) the by-pass filter gives greater engine wear and therefore the amount of foreign matter in the oil will be increased, (2) the by-pass filter removes more of the finer particles.

Conclusions

1. The full-flow filter, by positively filtering the whole of the oil supply, prevents by arresting rapidly the larger foreign bodies.

2. The by-pass filter is capable of arresting the larger foreign bodies, but as it only filters a small part of the oil supply, does not collect these particles at a sufficiently high enough rate to prevent considerable wear being caused by them.

3. The majority of the very fine particles are not arrested by the full-flow filter but are removed by the by-pass filter. The above tests show that these fine particles, however, are not of sufficient size to cause appreciable abrasive wear.

4. The oil is maintained in a visibly cleaner condition by the by-pass filter which over a period of time removes a large amount of the fine solid matter, mainly carbon. These tests show, however, that this visual appearance cannot be taken as any indication of the amount of damaging abrasive matter contained in the oil. Thus the full-flow filter gives good engine protection while the by-pass filter, though maintaining the oil in a cleaner state, gives relatively slight protection from wear. * * *

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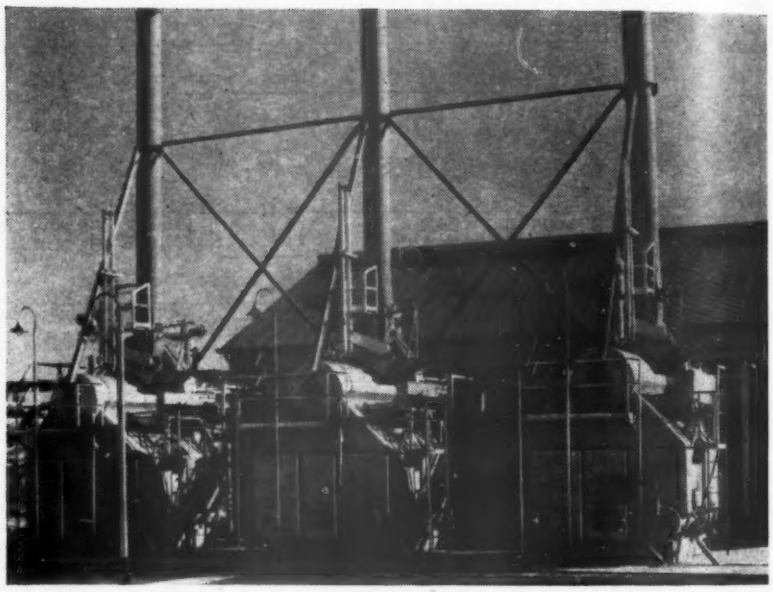

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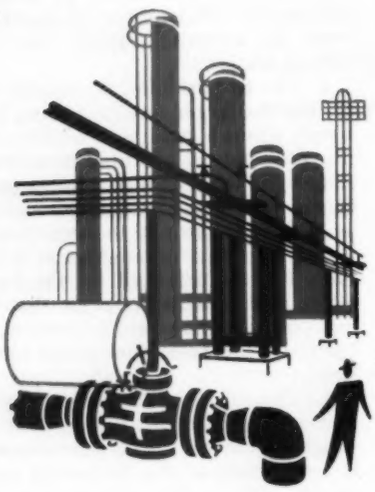

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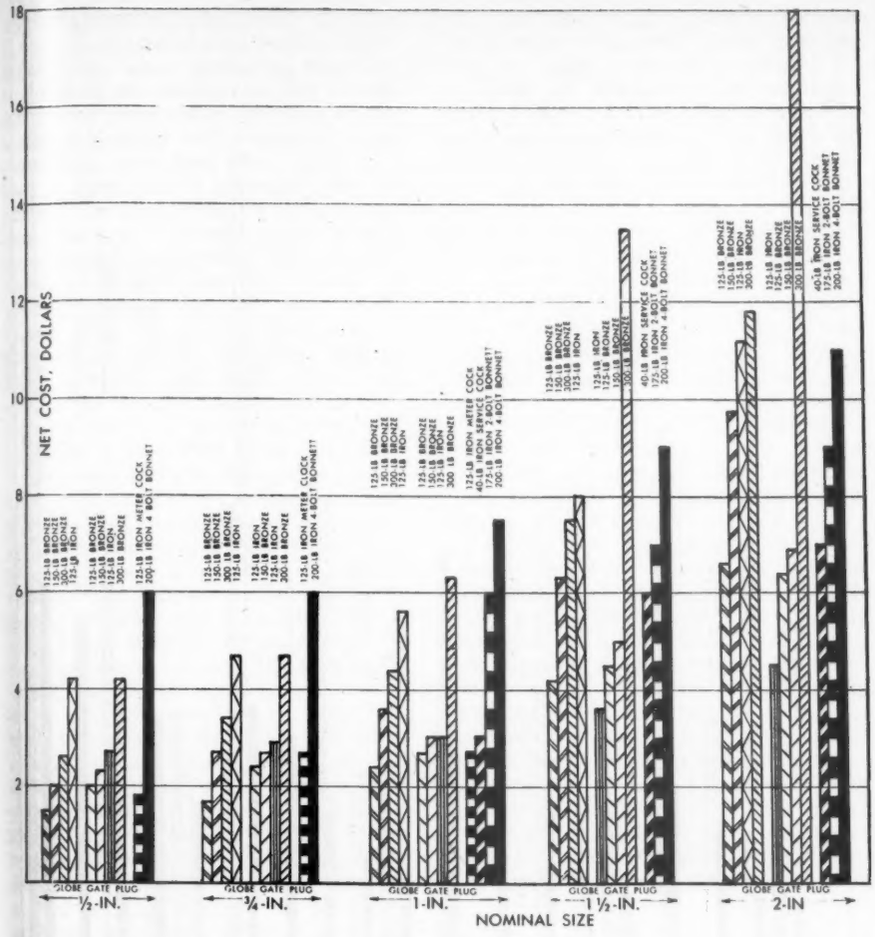

FIG. 1. Small utility valves — comparative costs.

GASOLINE PLANT DESIGN

PART 8 — SELECTION OF VALVES

O. L. LEWIS*

ALL valves fall into three loose classifications according to type. Block-valves are intended for complete shut-off. Throttling-valves are for regulating flow. Check-valves are used to prevent reversal of flow in a line. The two common types of block-valves are gates and plugs. Throttling-valves are nearly all of the globe or needle type. Gate-valves may be used for throttling but should not be expected to give a tight shut-off after being used for throttling services. Plug-valves are fine for throttling but cannot be adjusted as accurately as globe-valves.

Check-valves are predominately of three types. Swing checks, piston checks, and ball checks are most commonly used in plant piping. There are additional special designs and combinations of blocks, throttle, and check-valves. These special designs are usually applicable to a very narrow field of service and their use must be justified for each application.

Basic Valve Features

All valves are subject to many of the same requirements. They are the basic things to look for in valve selection. The specific valve features suiting a valve for a particular service can only be considered after the general principles of good valve design are established.

Standard Dimensions

There is no place for the odd-ball valve. It is true that in an original installation face to face dimension of a valve is not important as long as it is known before the time of installation. But if that valve type proves to be not satisfactory for the service it is practically impossible to replace unless both valves are made to standard dimensions. Standardization of dimensions effecting interchangeability has been accomplished through the efforts of API, ASA, ASME, and MSS. Users, distributors, and manufacturers all benefit.

General Design

Any valve specified must be reliable for long term, satisfactory operation. The valve should be simple, rugged, and compact, with a minimum number of parts. Watch for complex or delicate pieces that are difficult to manufacture to close tolerance or that require tricky assembly or adjustment. The valve should be designed so that disassembly and repair is reasonable under field conditions without specialized tools. Many times valves are not installed or maintained in ideal conditions.

Is the valve suitable for rough handling before and after installation? Is the design suitable for standing in one position long periods of time? Will it hold up when it is opened and closed several times a day? Is constant maintenance required to insure that the valve will operate when it is needed? These are all points that are effected by detailed valve design and vary from manufacturer to manufacturer.

Materials

There is general agreement between users, manufacturers, and Standards Associations on minimum properties of valve body materials. There is more discrepancy in trim recommendations. Even the bonnet gaskets and the bonnet bolting have a tremendous effect on satisfactory valve service. In comparing valve prices it is easy to overlook some of the reasons for price differences. Some of the dodges to cut prices should be watched. Two valves may be considered equal. Outwardly the valves appear much the same, but one valve has carbon steel bonnet studs, the other has alloy, one has integral machined seats, the other has special removable seat rings. One has a forged alloy wedge, the other has a cast carbon steel wedge. These are only material differences. In addition there are several design differences in depth of packing, stem attachment, and yoke arrangement. The cheaper valve is no bargain unless it is for use on a bargain service. The valves are certainly not equivalent.

Testing and Inspection

Don't pass over that general information in the front of the valve catalogue. It tells you the kind of a home that valve was raised in. Let's say the valve design is good. The features necessary for satisfactory service are incorporated in the design. Does the plant have the necessary facilities for correct manufacture in accordance with the design? Do they have facilities for testing and checking each part? Can you depend on uni-

*C. F. Braun and Company.

form quality? Was the product developed, properly tested, and the bugs worked out by research? Or is the manufacturer using your plant as a laboratory. Is the plant proud of its reputation? Is the testing procedure adequate to insure that every valve is up to specifications? Company background and the reputation of their product is as important as catalogue dimensions. If mother sleeps until Johnny has gone to school, you can't expect his hair to be combed every day.

Basic Body Materials

Common Materials. Four body materials are the basis for dividing valves into service classes. Bronze, iron, forged steel, and cast steel each have their application. Bronze valves are normally used in small screwed sizes only. They are used for water, air, condensate and low pressure steam. The bronze is more corrosion resistant and much more practical than a bronze trimmed iron valve in small size. Fig. 1 shows the relative prices of several bronze and iron valves in this class. Flanged valves for this service range are normally IBBM. The iron body is economical and the bronze trim insures corrosion resistance and smooth operation. The all iron flanged valve is suitable for low pressure, non-shock services like absorption oil and fuelgas.

Cast Iron. Now a word of warning, iron is brittle. Iron valves should not be used as the main block at the plotedge or on storage tanks below the liquid level in any area when fire is a possibility. If an iron valve is hit by a fire water stream while it is hot, it is almost certain to break. Iron valves are not intended for any service where breakage would add fuel to a flame or disrupt the supply of steam or water for fire fighting. Flanged iron valves may be used on low pressure, large size process gas lines at a saving. When they are used in this service, they should be buried or located away from the main plant area. That is unless there are other valves in a safe location that could shut off the flow of gas in case of fire.

Forged Steel. High pressure steam and process services are normally considered too critical for bronze or iron valves. Forged steel is the accepted material for screwed valves in these services. It is resistant to shock and high piping stress, not easily deformed by movement of the lines. The valves are rugged little things, easy to manufacture, and thus are economical to use in a great many services. Fig. 2 shows comparative prices of several classes of this valve.

Cast Steel. Cast steel is the accepted material for flanged process valves. Some manufacturers use carbon molybdenum steel for all valves 600 lb ASA rating and up. This material has higher yield strength and better creep properties. It is an added factor of safety in a tough service. Forged steel is also acceptable in this valve class. The forged steel body has all the advantages normally attributed to forgings but in general the manufacturing costs are higher

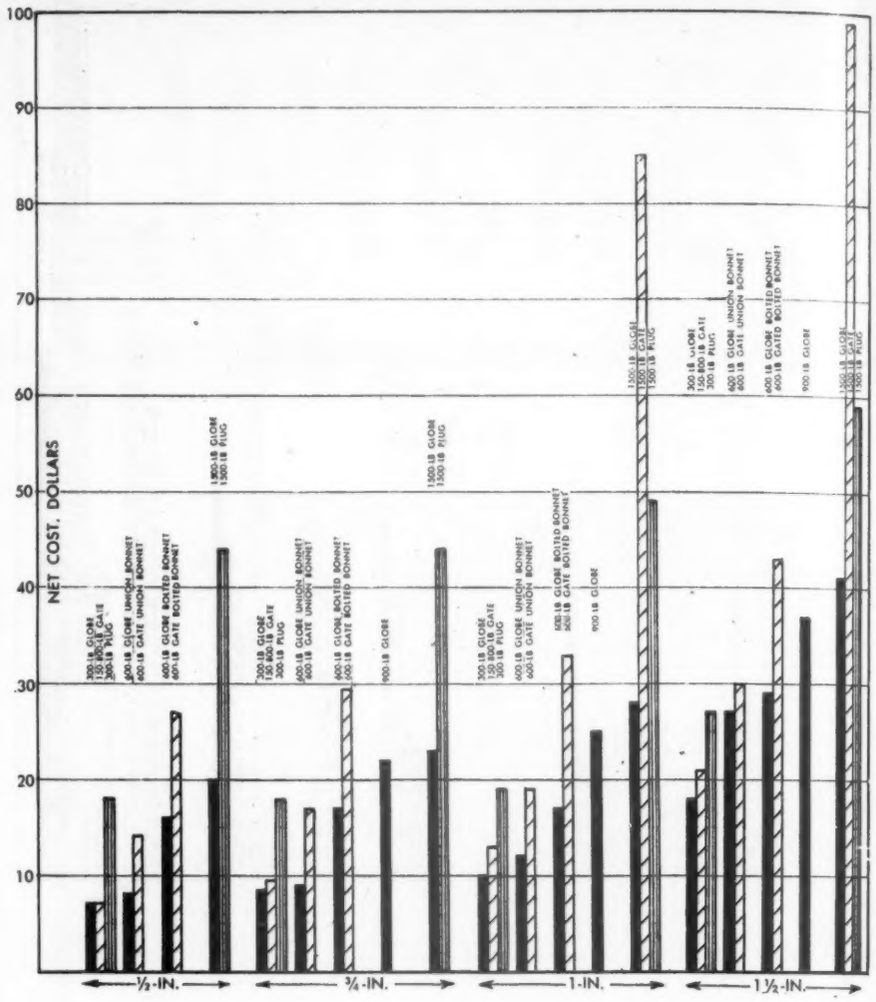

FIG. 2. Small steel valves — comparative costs.

than for a comparable cast steel valve. There is little question but what the forged valves are better than castings in some respects but they are not always economical in the services encountered in gasoline plants.

Gate Valves

General Features. All gate valves operate by raising and lowering a wedge or disc into a formed seat in the body of the valve. From this point on there are many variations in gate valve design. Gate valves are designed for use where low pressure drop and unobstructed flow are required. They normally are not specified when throttling control is needed. High velocity through a partly opened gate valve causes excessive wear on the seats and wedge. Then the valve will not shut off tight when necessary. Gates are sometimes used for intermittent throttling in sizes 8 to 24 in. When they are used for this service a second valve should be installed as a block valve.

One of the inherent disadvantages of a gate valve is the little pocket at the bottom of the valve between the seats. It may fill with foreign material and prevent the valve from closing. In cold climates in water service, the water trapped in this pocket when the valve is closed, freezes, expands, and often breaks the body of the valve.

Types. Gate valves can be divided into two general types. The double disc parallel seat and the wedge disc taper seat. The double disc type is easier to regrind and maintain than the taper seat type. The double disc type, however, is not generally used except in iron body valves for low temperature and medium pressure service. The wedge disc type has fewer moving parts and is usually preferred for steel and alloy valves in high pressure and high temperature service. The solid wedge is better suited for rough service. Solid wedges are sometimes furnished with a welded metal facing of special or hard material when it is required because of corrosion or high pressure, high velocity gas streams.

The OS&Y type valve is preferred for practically all gasoline plant services. The stem threads are outside the valve and not in contact with the line material. The inside screw type valves have the threads exposed to the material flowing in the line and are subject to any corrosive effects of that material. Rising stem valves are usually preferred because it is easy to tell at a glance whether the valve is open or closed and if it happens to be half way between, even a green operator can tell whether he is opening or closing the valve.

Design Features. Satisfactory valve service is dependent to a degree upon

several points of design. Once the type of valve is determined it is well to watch these points when comparing the valve of different manufacturers. The T head method of connecting the stem to the wedge is simplest and strongest. A pin connection may bind the wedge and keep it from seating properly. And the pin may be sheared off in valve operation. The type of bearing used to take stem thrust is important in larger high pressure valves. Bronze yoke sleeves are usually suitable for 150 and 300-lb valves. Some method of lubrication is desirable in the 300-lb class. Ball or roller bearings used with alloy yoke sleeves are desirable in the 600-lb class and practically a necessity for ease of operation in the 900-lb class and above.

Seats and Wedges. Integral seats are fine when the service permits but removable seat rings have a lot of advantages. The integral seat ring is applicable primarily to bronze or all iron valves. When bronze or alloy trim is required, separate seat rings are a necessity. Three methods of attaching seat rings are in common use. The weld metal facing, the screwed-in ring and the rolled-in ring. Screwed-in seat rings are used most commonly. They are desirable in bronze trimmed iron valves and in alloy trimmed steel valves. When screwed seat rings are used in steel valves subject to high pressure and temperature, they should be backwelded to positively prevent leakage around the ring. It is really in these high pressure, high temperature services that the welded seat facing and rolled-in ring have the greatest application. Of course the welded and rolled rings can not be replaced except in a well-equipped valve shop. For that reason they are not considered preferable in valves in the lower pressure class.

Trim Materials. The seat wedge and body material also influence the type of seat rings used. Bronze rolled-in seat rings are fine in cast iron valves. They are not used at high pressures or high temperatures and the softer bronze ring gives a better seal with less stem pressure. Steel valves used for temperature service are a different problem. The wedge and its trim are important, too. A rolled-on wedge facing will tend to loosen due to the difference in the coefficient of expansion of the wedge and wedge trim material. So for higher temperature applications a solid wedge of the trim material for smaller valves or a steel wedge with a weld metal trim facing for larger valves is preferred.

Effect of Hardness. One manufacturer points out another advantage of a weld metal wedge trim. "The disadvantage of rolling a stainless steel 12 per cent chrome ring onto a carbon steel wedge is that the maximum Brinell hardness that the ring will roll is about 260 Brinell. With a deposited weld metal face we are able to maintain a minimum Brinell of 320 with an average of around 350. With a 12 per cent chrome trim valve, they average about 250 Brinell and the wedge facing runs around 350 Brinell. This difference in hardness reduces greatly the tendency of galling between like material."

Points to Compare. There are other general points of comparison. Is the wedge guided through its full travel? If not the valve will chatter when it is being opened and closed and the seat or wedge may be damaged. Valve wheels take a terrible beating when a hefty farm boy hooks one with a hickey or a cheater and bears down. Is the valve wheel iron or steel? What type of gland packing is required and how many rings will go in the stuffing box? The mark of a cheap valve is a shallow stuffing box. Does the valve have a bonnet bushing for a back seat when it is wide open? Some of the well-known valves do not have this feature and the valve cannot be repacked under pressure.

The pitch of the stem thread may be important if the ease of opening or speed of opening or closing the valve is important. Table 1 shows the number of turns required to open valves of two different manufacturers. Notice that there is a wide variation. It is standard practice to use a single lead thread for steel valves and a double lead thread for iron valves. The primary reason being that more pressure is required to effect a tight seal in a steel valve. Overall valve satisfaction depends upon knowing the valve service and watching the design features to insure that the most suitable valve is actually provided.

Small Gates. The design features of small screwed gate valves are as varied as the larger ones. Some of the same factors are involved but the emphasis is different in the smaller valves. The bonnet joint is still critical. Valves for very low pressure general service use a screwed bonnet. The next higher pressure class valves use a union bonnet connection. Small valves for higher pressures and rugged service are usually either bolted or welded bonnet type. Quite often small screwed valves are installed as block valves on the end of small nipples. Weight is a definite disadvantage in that application. The welded bonnet valve is lighter than any of the other forged steel types and just as rugged as either of them.

The seats in small valves are not easy to regrind. So they should be of material that will give long service. Integral or rolled-in seats are found in the best quality valves. Wedges should be solid and of the trim material. The parts are too small for hard facing to be much economy. The precision and accuracy of manufacture are important items in small valves. And they are items that can only be checked by experience. The packing gland is a point to watch in comparing small valves. Is it bolted or screwed? How many rings of packing will it take?

Flow Area. One of the favorite methods of cutting prices in small steel valves is pretty well hidden. Some manufacturers use an undersize body with enlarged connecting ends. The actual flow area is at times less than 50 per cent of the flow area of the pipe attached to the valve. Fig. 3 shows comparative flow areas of standard nominal sized valves of four major manufacturers. The smaller port area does not necessarily hurt you if you know it is there but you are entitled to know what you are buying.

Plug Valves

General Features. The plug valve is another type of block valve. It is faster opening than a gate. One quarter to one full turn is all that is required to fully open and close a wrench operated plug valve. The opening through the valve is smooth and straight and neither of the seating surfaces are exposed to the flow in the open position. There is no pocket in the bottom of the valve to accumulate scale and hinder proper seating of the valve. For these reasons the plug valve is considered a more positive block than the gate valve. They are particularly applicable to high pressure, light hydrocarbon service. Several companies require double valving of critical services if gate valves are used but accept one plug valve as the equivalent of the two gates.

Body Types. Plug valves are made in several patterns and types. The short pattern plug has the same face to face dimension as gate valves, and the dimensions are standard with all manufacturers. This pattern makes it necessary to use plugs with port openings smaller than nominal pipe size. The amount of port restriction varies with rating and size. Even the reduced size opening causes about the same pressure drop as a gate valve, as the opening is smooth and less turbulence is introduced. In addition to the gate valve dimension plug, most series valves are available in regular and venturi patterns. In small sizes, 4-in. and under, the regular pattern has the same dimen-

TABLE 1. Number of turns required to open valves.
OS&Y rising stem valves
Iron and steel

	Gate valves									Globe valves							
	125	150		300		600		1500		125	150		300		600		1500
	A	A	B	A	B	A	B	A	B	A	A	B	A	B	A	B	A
1½"	..	..	12	15½	12	13½	12	10	9	..	..	..	..	8	6	10	6
2"	7	15	13	15	13	15	13	10	10	6	7	9	6	7	7½	9	7½
3"	10½	17½	18	14	14	15	14	14	13	5	10	9	10½	12	10½	10	5
4"	9	19	18	19	18	19	18	19	17	6	11	14	12	12	8	9	6
6"	13	27	26	27	26	28	26	24	24	7	17	16	12	11	9	..	10
8"	17	36	34	35	34	32½	34	32½	30	10	9½	10	7½	..	..	..	..
10"	21	44	42	38½	42	34½	..	38	..	14	..	..	..	..	..	..	..
12"	25½	53	50	45½	50	47	..	45½	..								
14"	30	53½	55	41	55	51	..	50	..								
16"	34	60½	63	61	63	60	..	..	..								
18"	38	69	..	65	..	65	..	..	..								
20"	42	75	70	73½	..	72	..	..	..								
24"	50	89	84	87	..	74	..	..	..								

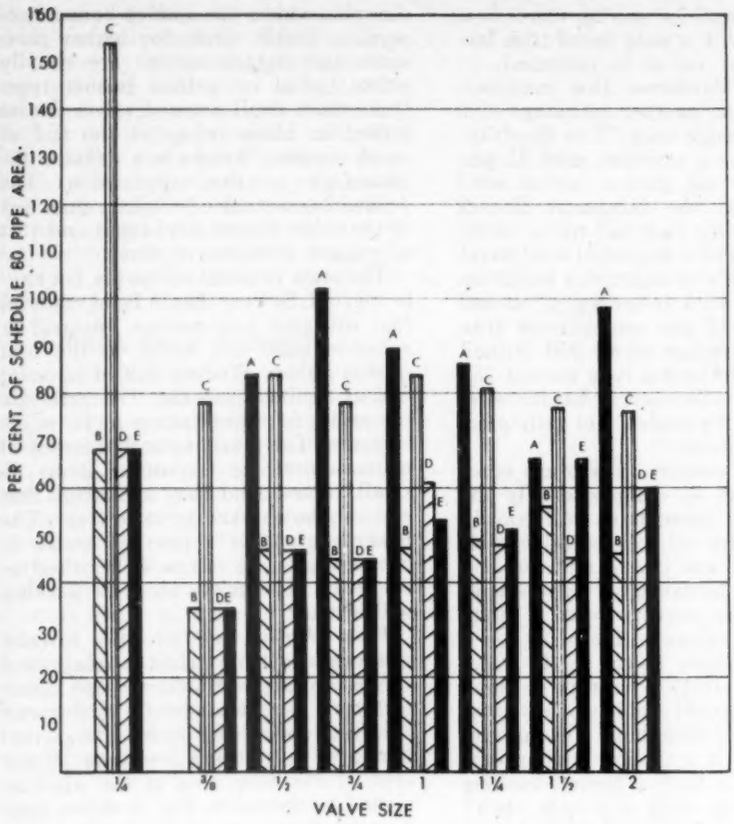

FIG. 3. Flow area. Standard screwed gate valves — forged and cast steel.

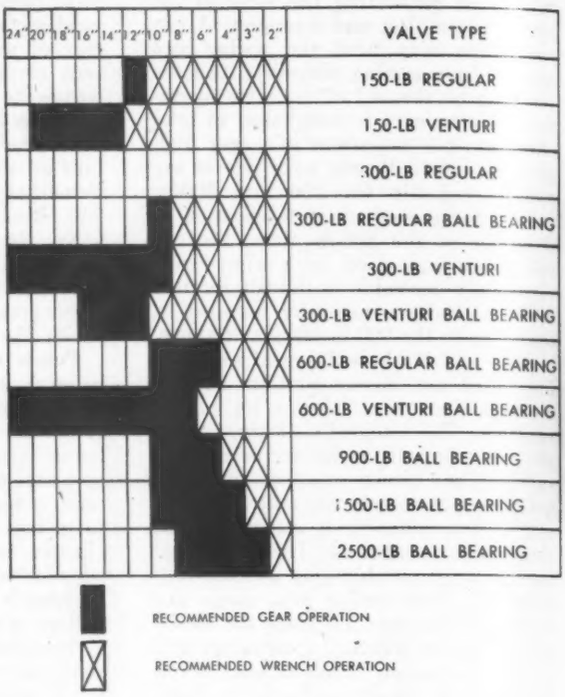

FIG. 4. Plug valve operation chart.

sions as the short pattern. And they are one and the same. Some venturi pattern plugs in large sizes have gate valve face to face dimensions.

The short pattern plugs are usually less expensive than the regular pattern and the cost about the same or a little less than the venturi pattern. The higher pressure drop is usually not enough to justify the higher cost of the other types. Also the interchangeability with gate valves is a desirable feature. Because of the restricted face to face dimension it is necessary to use tapped holes and stud bolts for flange bolting in some sizes. This feature is somewhat of a disadvantage but is not critical.

Regular pattern plugs are considerably longer and usually more expensive than the short pattern. The additional cost can only be justified when pressure drop is essential. Venturi pattern plugs have ports only 30 to 50 per cent of the nominal pipe diameter. They are designed for a minimum pressure drop. The design of the throat approximates the venturi and a large portion of the original pressure loss is recovered in through flow. Due to the smaller plug, venturi valves are easier to operate and usually can be wrench operated one size larger than the regular plug.

Round port, full bore pattern plugs have circular ports equal to the nominal diameter of the pipe size. Because of the large plug required for this type of port, the valve is considerably longer than any of the other types and is more expensive. The round port is used only when full pipe area is required. About the only application for this valve is for valving under a relief valve.

Operation. Plug valves are wrench operated in the smaller sizes and lower pressure classes. Fig. 4 shows the approximate range where gear operation becomes desirable. Both worm and spur gears are available for gear operation. The worm gear type has a higher gear ratio and is smoother operating. It is recommended when the side location of the hand wheel is not objectionable.

Lubricated Plug Valves. The lubricated plug valve depends for a seal upon a lubricant forced into grooves under high pressure. In order for the lubricant to be retained under pressure, it is necessary to have an accurately tapered fit between the body and the plug. Body deflection must be held to a minimum to maintain this fit. Most lubricated plug valves have a lubricant chamber under the bottom of the plug. It serves as an aid to unseating the plug if the valve has any tendency to stick. In higher pressure valves the same lubricating system may help to seal the stem joint. Either an inverted plug or a ball bearing arrangement must be used in high pressure service. Either feature is an aid to controlling the upward thrust of the plug due to line and lubricant pressures, and prevents the packing gland from forcing the plug tightly against the seat.

Lubricant. The lubricant used in a lubricated plug valve is just as critical as any valve part. The lubricant must be stable, and not react chemically with the line fluid. It must be suitable for the entire temperature range of the service conditions. It must flow freely enough at all temperatures to reach all working surfaces and yet be viscous enough to effect a lasting seal. It must have no tendency to solidify, due to age, temperature, or service. That sounds like a tough job but there are quite satisfactory lubricants available for practically all gasoline plant services. Each manufacturer designs his valve to use lubricants with specific properties. The safest bet is to use the lubricant recommended by the valve manufacturer unless extensive tests have shown another lubricant to be more satisfactory. It is important to repack and lubricate plug valves before putting them in service. The assembly lubricant for testing the valves is not normally suitable for hydrocarbon service and it is not replaced with the proper material at the factory except by special order.

It is important to use the right lubricant but also it must be used at the right time. Lubricated plug valves should be lubricated regular and at set intervals. That means a maintenance schedule if satisfactory operation is assured. That brings us to the major limitation of lubricated plug valves. Present lubricants are only good for operating temperatures up to 450 F to 500 F so the lubricant sets the maximum service temperature. Fig. 5 shows comparative costs of lubricated plugs, gates and globes in the normal size range. Fig. 6 compares costs of gates and lubricated plugs in larger sizes.

Dry Plug Valves. To get away from the bother of lubrication schedules and temperature limitations, the dry plug valve was developed. It depends entirely upon metal-to-metal contact for a seal,

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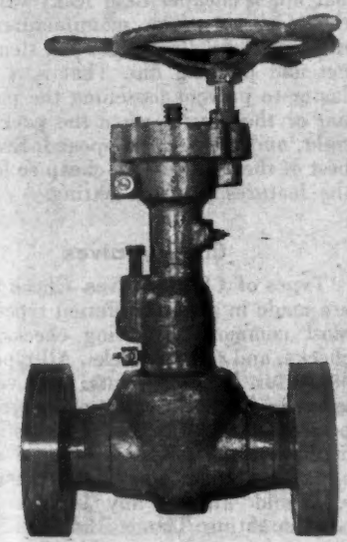

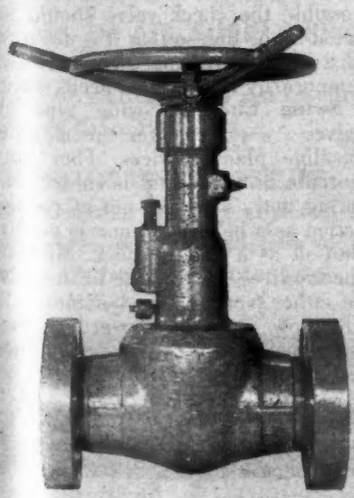

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ORBIT FORGED STEEL VALVES have been designed with a friction free seating principle. To the operator this means longer service at lower maintenance costs because the absence of friction in seating means greatly reduced wear at the point of seat contact. Since there is no contact between the core and the body, or the core and the body seat, there is no rubbing or scuffing of the valve seating surface.

The extreme ease of operation of Orbit Rising Stem Valves is due to this fact; Fluid loads acting on the valve seating core are applied on the trunnions, rather than on the spherical seating surfaces, thus reducing the frictional lever arm to a minimum, as well as the torque necessary to rotate the core.

The ORBIT VALVE taken as a whole is a precise piece of mechanism, machined to close tolerances, assembled and tested under skillful supervision because it is designed to be depended upon for an easy and positive shut-off (even under adverse conditions) and must stand up mechanically without failure when put to the services for which it has been recommended.

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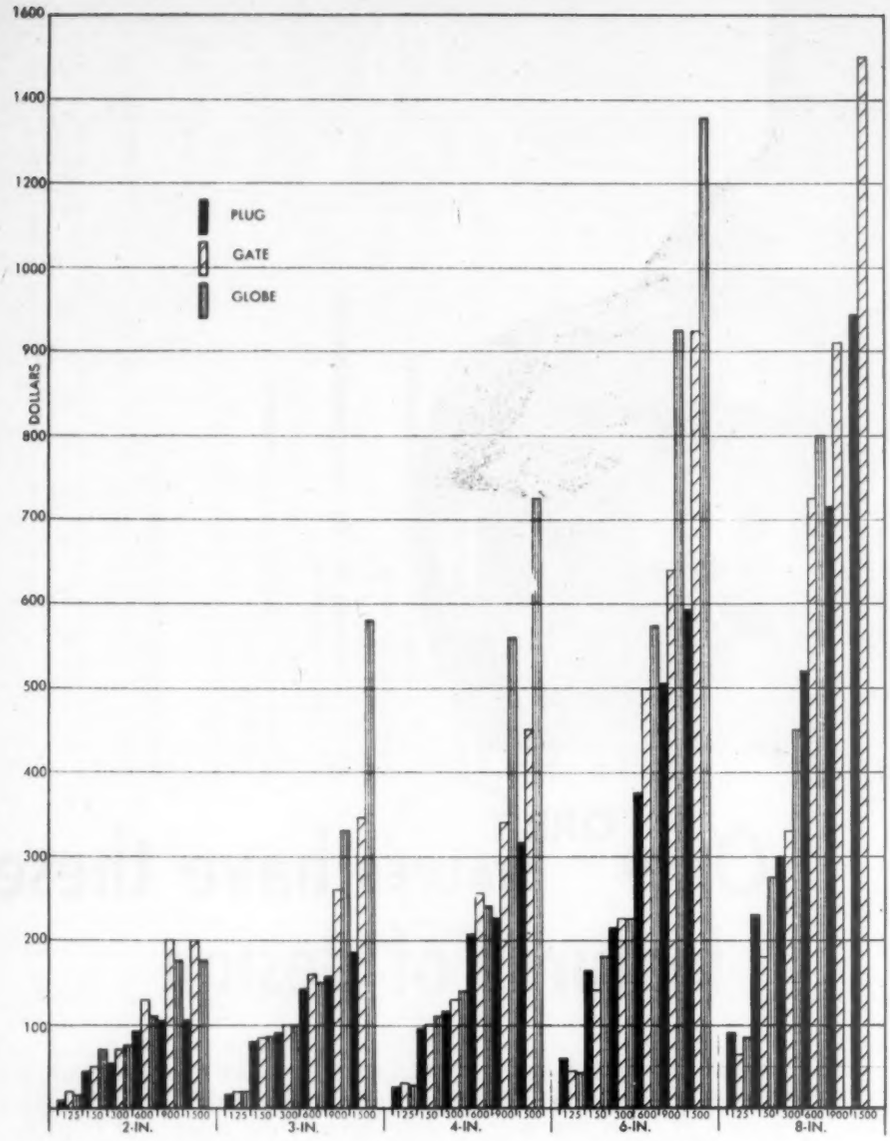


FIG. 5. Flanged valves — plug, gate, and globe. Comparative costs.

otherwise the principle of operation is the same as the lubricated plug.

The valve design must incorporate some method of separating the seating surfaces before the turning action is begun. There are several manufacturers of dry plug valves. The difference in design is due primarily to the method used to turn, lift and seat the plug. Some of these mechanisms are made up of a great many intricate parts. The simplest mechanism is usually the most satisfactory.

The primary application of the dry plug valve is where it is desirable to retain the other features of a plug valve without the inconvenience of lubricating or the limitation of higher temperatures. In general the dry plug does not provide as positive or as permanent a seal as the lubricated plug, that is, in the temperature range where the lubricated plug is applicable.

Throttling Service

Globe Valves. Globe valves are designed primarily for throttling and flow regulation. They can be used as a block valve if the higher pressure drop is not objectionable. Too, the cost is well above gate valve cost. Fig. 6 shows the cost comparison over the normal size range. Globe valves 1½-in. and smaller are suitable for most services when the additional pressure drop is not objectionable. Globe valves larger than 6-in. size are hard to justify. They are very expensive compared to other valve types and extremely close throttling is not usually required of the larger size valves. A plug or gate type valve will throttle just as accurately and much more economically.

Globe valves are made in two general types. Swivel disc and integral plug disc. The integral plug disc has the plug made integral with the stem. Rotation of the disc in seating is supposed to grind out any foreign deposit on the seat as it closes. The swivel disc valve has a loose disc, which is not forced to turn with the stem. This type disc is free to locate its own seat without the restriction of the stem. And it has no grinding action on the seat. Swivel disc valves seem to last longer in general services. They are more apt to give a tight shut off. For these reasons they are more widely used than the integral plug type. It is questionable whether the grinding action of the integral plug is an advantage or disadvantage.

Many small globe valves in bronze and iron use a renewable composition disc. Higher pressure globes use metal-to-metal seats similar to the seal at a ground joint union connection. Both types have definite fields of application. The renewable seat must be renewed but the integral seat may last a long time.

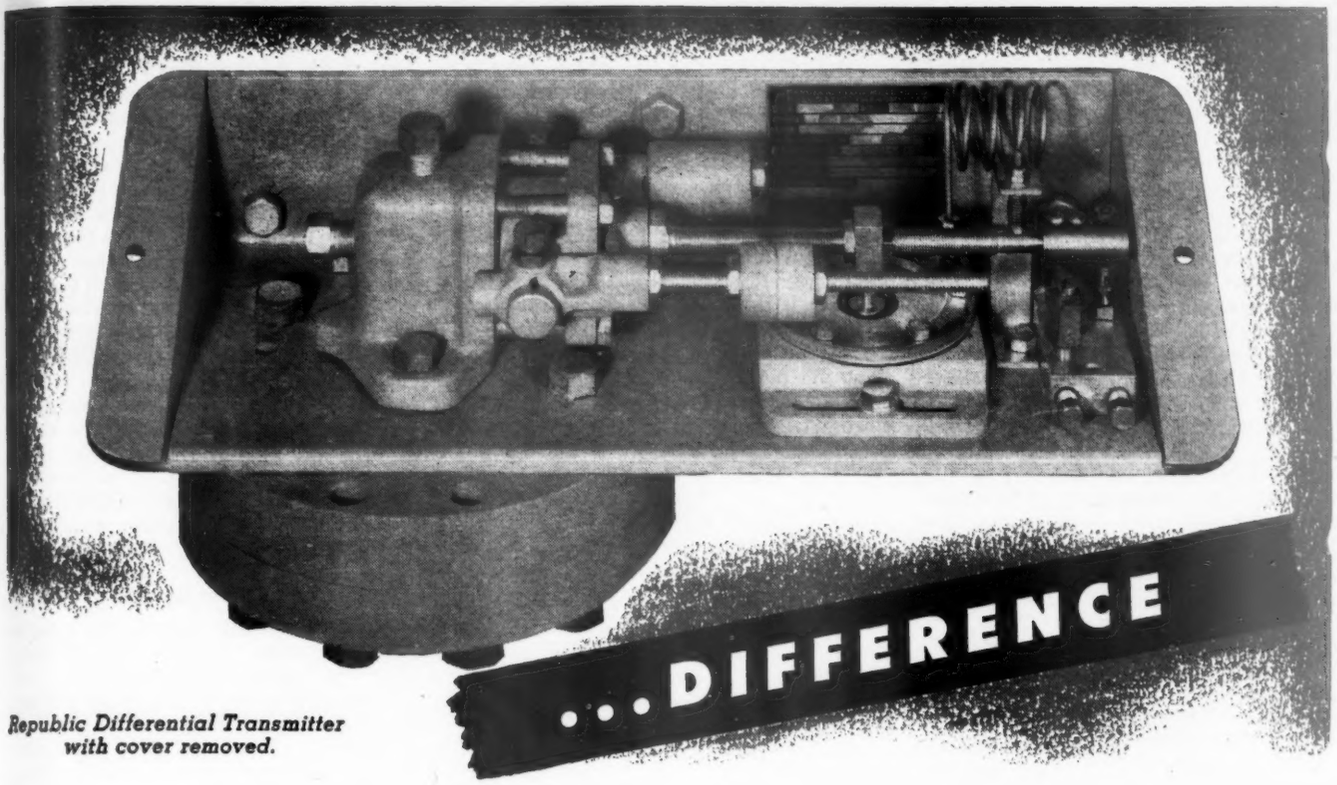
Barstock Valves. The barstock needle valve is a specialized type of throttling valve made in small sizes. Its main application is in instrument service and for small pressure bleeds. The barstock valve is a simple rugged valve, well suited to its service. The critical points of comparison are the workmanship, the materials and the bonnet joint. The valves are simple but good workmanship and close tolerances are necessary if the valve is to give a tight shut-off. The stem is machined to fit a seat machined into the body. So the stem seats with a turning action. Materials must be nongalling to insure continued tight shutoff.

Some bonnets are screwed into the body with a standard thread. A tapered thread at this point is much more satisfactory. The best barstock valves have a ground joint union bonnet connection. They are more expensive in original cost but much cheaper than leaky valves in the long run. Some manufacturers use different thread pitch for the stem bonnet and packing nut. That is a safety factor to prevent loosening the packing nut or the bonnet when the packing is tight, and the valve is opened. Even the best of these valves are cheap so look at the features you are getting.

Check Valves

Types of Check Valves. Check valves are made in several different types. The most common are swing checks, ball checks, and piston checks. All types are made for both horizontal and vertical service. A check valve cannot be depended upon for a positive shut-off. Two manufacturers have made extensive tests and claim that their makes positively will hold without any leakage. Let's play doubting Thomas here and take this recommendation with a grain of salt. What happens when a small piece of foreign material gets on the seat? If possible the check valve should be located in the line so that it is downstream of a block valve that can be closed off temporarily if the check needs servicing.

Swing Checks. Swing type check valves are suitable for the majority of gasoline plant services. They are not suitable in a line that is subject to pulsating flow. They are not as positive of action as a ball check nor as positive of shut-off as a piston check. Most swing check valves are suitable for installation in either vertical or horizontal lines. The flow must be upward through a check valve installed in an inclined or vertical line. Only a few swing check valves are so made that the disc falls back out of the line of flow and will not close when installed vertically. This point should be checked with the sup-



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plier before his valves are specified for vertical installation.

Swing check valves can be obtained with an outside lever and adjustable weight. The weight may be adjusted to just balance the disc so that the valve completely opens at a low flow rate and closes a little slower, or it may be adjusted to actually assist the disc in closing. The later arrangement makes the valve slower opening and faster closing. The faster closing valve nearly prevents flow reversal and thus reduces line shock that would be caused by reversal of flow. Actually the pressure required to lift the disc of a standard swing check valve is negligible. Test results on 3 to 6 in. standard valves show the following results.

The lifting pressure varies with the weight of the moving parts. A few tests on larger size valves indicate that the lifting pressure increases almost in direct proportion to the valve size.

Description	Weight of moving parts, pounds	Pressure psi pounds to lift disc
125# C I	7.8	.022
150# Steel	12.9	.043
300# Steel	16.3	.072

Non-Slam Checks. One special type of swing check is suitable for lines subject to some pulsation. The disc is balanced near the center and seats on an inclined plane. The special arrangement of the non-slam valve practically prevents chattering. It is applicable in services where a normal swing or ball check would beat itself to pieces.

Ball Checks. The ball check valve is the simplest and has fewer parts than any of the others. They stop flow reversal more rapidly than most other types. The ball check has definite advantages in any service subject to corrosion or deposits of foreign materials. The moving ball keeps the seat pretty well cleaned off and there are no pivot points or close tolerances to get gummed up. A ball check is not suitable for lines with varying or pulsating flow. They rattle like a wagon and eventually get too beaten-up to depend upon.

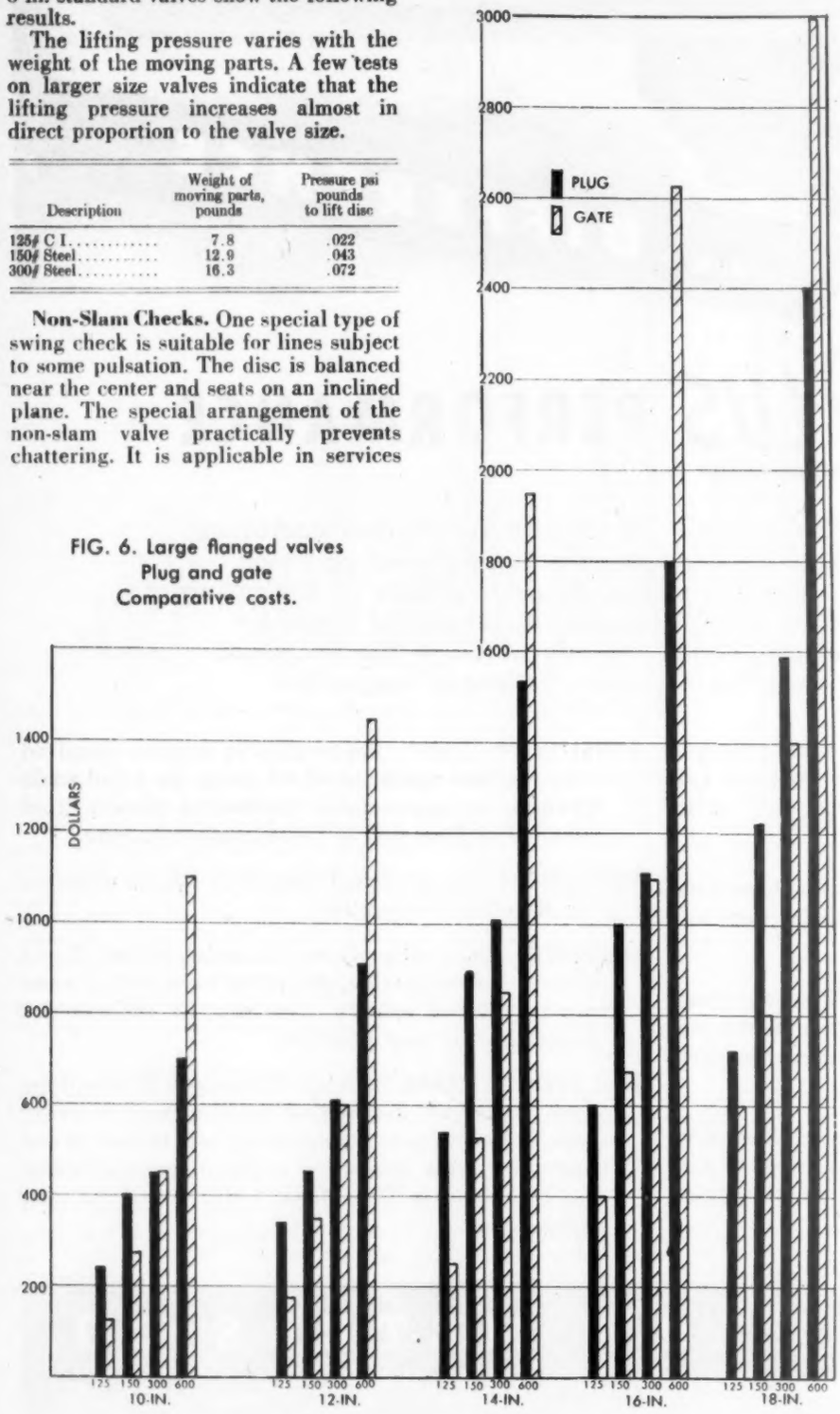


FIG. 6. Large flanged valves
Plug and gate
Comparative costs.

Piston Check. The piston check is more suitable for pulsating flow than any of the other standard types. It is used primarily on compressor discharges and high pressure reciprocating pump discharges. The piston type check is relatively slow closing as the flowing material provides a cushioning effect. The speed of opening and closing can be varied by changing the orifices that control the balancing pressure that opens and closes the valve. Gas and oil require different orifice size so the service must always be specified. The valves are made for both horizontal and vertical service. Piston checks are normally spring loaded for fluid service and should always be spring loaded when the valve is for installation in a vertical line. Piston type check valves are not recommended for any dirty service that would tend to clog the orifice ports or gum up and prevent movement of the piston.

Summary

Application. The satisfactory operation of a plant is entirely dependent upon the satisfactory operation of the valves in the plant. It is necessary to be familiar with the design characteristics of the various valves in order to specify the valve most suitable for specific service. Local conditions and experience vary from plant to plant so no standardized valve specification will apply for general use. Figs. 1, 2, 5, and 6 show valve costs by types. The costs plotted are list prices less actual quoted discounts in January of 1950. Of course valve costs are considerably higher today but the 1950 costs were thought to better represent comparative valve values over an average period of time. These costs are given to show the economic advantage of varying valve specification depending upon size and pressure rating.

Specification. The correct valve must be specified, and bought. The supplier must be given enough of the service requirements to furnish the valve for the service. Extremely detailed specifications are not necessary. In fact they are often a disadvantage because they may rule out a competitive valve that is entirely satisfactory. It is better to avoid unsatisfactory design details by leaving those valves off your supplier list than it is to try to write a long winded exclusive specification. The following points should be covered in the valve specification to help the buyer and the supplier and to insure that we get what we want:

1. Identify the valve by manufacturer's name and figure number.
2. Give size and connecting flange rating and facing.
3. Show valve service. What fluid or gas is it supposed to hold? This is particularly important for check valves and lubricated plug valves.
4. Point out any special corrosive conditions.
5. Specify trim and body materials that vary from standard for figure number called for.

Part 9 in this series will be published soon.

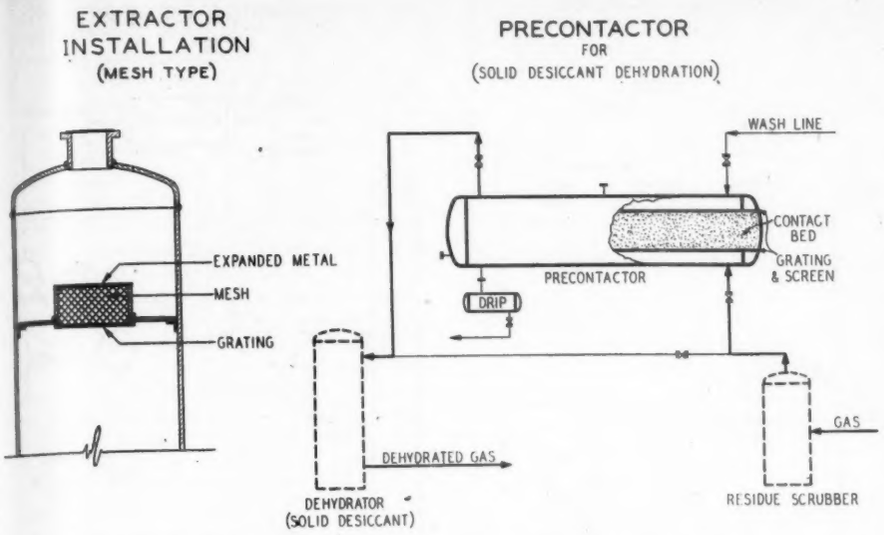


FIG. 1. Typical mesh type extractor installation in top section of vessel.

FIG. 2. Precontactor chamber used upstream from dry desiccant dehydrator to remove oil from gas stream.

Absorption Dry Distillation and Underground Storage†

R. L. LANE* and B. J. THOMPSON**

Use of the absorption process to recover light hydrocarbon components from natural gas and distillate streams has been common for many years. Two decades ago, satisfactory methods of predicting low pressure absorption operations were available. However, the increasing demand for high pressure residue gas delivery to gas transmission companies, the rapidly expanded LPG markets and the return of gas to oil reservoirs for secondary recovery purposes have dictated the operation of intermediate and high pressure absorbers. Many design and operating problems in high pressure absorption systems still remain unsolved. This paper considers primarily absorbers operating at pressures of 500 to 1200 psig in the intermediate pressure range.

A few of the operating problems encountered in the intermediate pressure range of absorber operation will be discussed.

*Chief engineer, manufacturing department, Warren Petroleum Corporation, Tulsa, Oklahoma.

**Process engineer, manufacturing department, Warren Petroleum Corporation, Tulsa, Oklahoma.

†Presented before Natural Gasoline Association of America, Houston, Texas, April 30, 1952.

Oil Loss

The carry-over or loss of absorption oil overhead from the absorber with the residue gas stream presents several significant problems among which are: (a) The cost of make-up oil lost from the absorption system and (b) the fouling of dry desiccant type dehydrator beds.

Various operators have employed different methods of counteracting the oil loss from the absorber, which include: (a) feeding of the absorption oil two or more trays below the top of the tower, (b) use of 210 to 230 molecular weight oil instead of the 160 to 190 molecular weight commonly used in plants extracting high percentages of propane, (c) internal tray and chimney type mist extractor units, (d) use of vane type mist extractor elements that have been installed in the top of the absorber, in the residue scrubber and, in some cases, in the residue gas line downstream from the scrubber, (e) use of mesh type extractor elements ranging from 4 to 6 in. thick, some of which cover the full diameter of the absorber and others are installed in a holding case with a predetermined cross sectional area based on gas velocity of 1 to 4 ft per second and (f), providing a residue gas contact chamber packed with an adsorbing medium such as bauxite.

We have used the various types of extractor elements and found that most units remove mechanically entrained liquid satisfactorily from gas streams. The problem of removing oil fog from an absorber residue gas stream has not been solved in our operating experience. We trust other operators present will have favorable experiences to report on this problem.

In an effort to solve this extraction "toughie," several mesh type elements, as shown in Fig. 1, have been installed in the top section of absorbers and residue gas scrubbers.

Operating experience has proved that the mesh element must be installed in a horizontal position. Several operating observations show a substantial reduction in the quantity of oil lost overhead from the absorber and residue gas scrubber when using a mesh type element.

Use of a precontactor unit as shown in Fig. 2 has proved that a very significant reduction of oil entering the dehydrator may be effected. Minimizing the amount of oil reaching the solid desiccant bed extends the ultimate desiccant life and makes possible a lower average dew point of the effluent gas from the dehydrator.

Oil collected in the precontactor drip may be manually or continuously drained. Spent desiccant is a satisfactory contact material for the precontactor. Other materials, however, may be employed that provide good adsorbing characteristics, such as silica gel, solva beads, and charcoal.

Solid desiccant in dehydrators and precontactors may be regenerated to approach its original efficiency by washing with natural gasoline or butane.

Foaming

Oils containing aromatic compounds appear to cause considerable foaming within the absorption process.

The desirable solution for the absorption oil foaming problem is to use an oil which has proven in operation to be satisfactory. There are numerous foam arresting compounds recommended for injection into the absorption system. The defoaming treatment has proved quite satisfactory to some operators.

Temperature Rise

The increase of absorption oil temperature, referred to as heat of absorption, as it flows down through the absorber must be coped with to maintain an optimum absorption efficiency.

The most common method of removing heat from rich oil in the absorber due to heat of absorption is by the use of intercoolers. These units consist of a liquid draw-off tray, a low-head pump, and water cooled exchanger or atmospheric cooler. This type unit may be

used from one to several times in one absorber as required depending on the richness of the gas and the per cent of absorption desired. A special base cooling unit is being employed very satisfactorily in plants absorbing rich gas. The base cooler unit is fed with rich gas and rich oil. The simultaneous absorption and cooling effects substantial absorption of propane and increasingly greater quantities of heavier hydrocarbons in the base cooler. Some intercooler systems consist of internal tube bundles mounted inside the absorption vessel, which are cooled with water or a refrigerant circulating through the tubes.

Overload

Many operators have been confronted with the problem of handling a volume of gas considerably in excess to the design capacity of the absorber. The overloaded condition contributes to the previously enumerated absorber operation problems.

In some cases the increased load above the original design capacity is of such magnitude and projected duration to economically justify the installation of an additional absorption unit to operate in parallel with the original unit. In cases in which the average tray specifications or dimensions have been used, it is possible to redesign the existing trays for higher capacity or to replace trays with units having high capacity for the additional liquid and vapor loading.

Several tray designs are now on the market which the manufacturers claim will increase the capacity of the average existing absorber by as much as 50 per cent.

Energy Conservation

Numerous absorption plant process arrangements include a major loss of available energy when the rich oil is flashed from absorber pressure, range 500 to 1200 psig, to the rich oil flash tank pressure, which is commonly in the range of 200 to 300 psig.

Recent installations have been made to utilize this available energy in the relatively high pressure drop from absorption to flash tank pressure. The high pressure rich oil is circulated through a hydraulic or rotary unit used as a driver that is coupled to a similar unit utilized to pump some stream. A typical installation is to pump the lean absorption oil to the reabsorber. This type installation and others that may be worked out, offer attractive prospects for conservation of prime power by eliminating one or more electric or steam driven units. It is possible to recover as high as 70 per cent of the available energy by the use of such a unit.

Dry Distillation

Before entering the discussion on dry distillation let us review briefly the general operating scheme of the various absorption oil stripping units.

Some operators are continuing to utilize the early day two-section distillation unit in which the first vessel is the stripping section from which the raw product vapors are delivered to a second tower known as the dephlegmator. Cool water is circulated downward through the dephlegmator to condense the raw product vapors from the stripping section. The presence of water in this type system, which originates from stripping steam and dephlegmator water, is a continuous problem due to corrosion and the additional load placed on product dehydrating facilities.

A common stripping scheme is to feed the preheated rich oil direct to a combination unit which consists of stripping and rectification sections in one vessel as shown in Fig. 3.

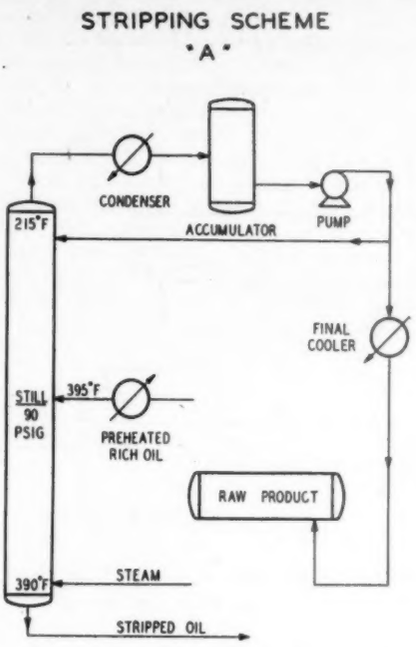


FIG. 3. Typical steam distillation flow scheme.

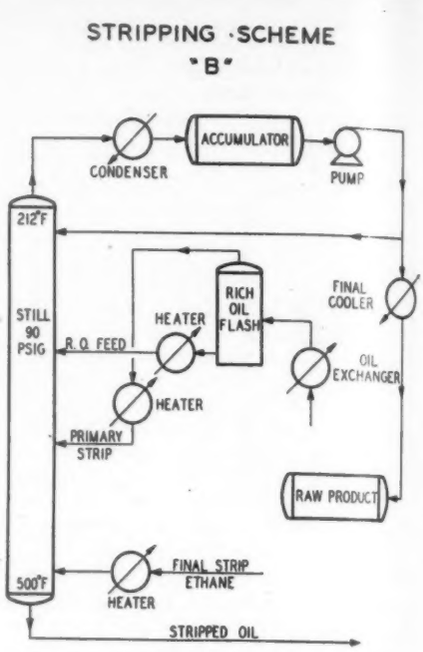


FIG. 4. Typical combination hydrocarbon stripping scheme.

In this system most of the hydrocarbon product will flash at or near the feed tray. Final stripping is accomplished by the introduction of steam below the bottom tray.

Some plants employ a multiple distillation system, using the primary or high pressure unit for maximum product condensation and the secondary or low pressure unit for the final separation of the gasoline from the oil. This system is particularly applicable in plants processing distillate.

In the past few years we have developed a dry distillation system that has

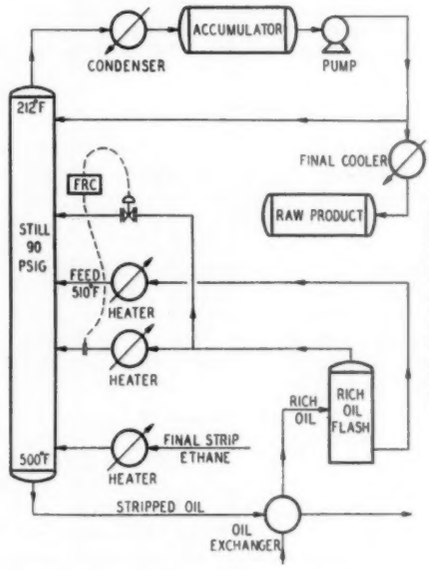


FIG. 5. Combination hydrocarbon stripping utilizing excess vapor feature.

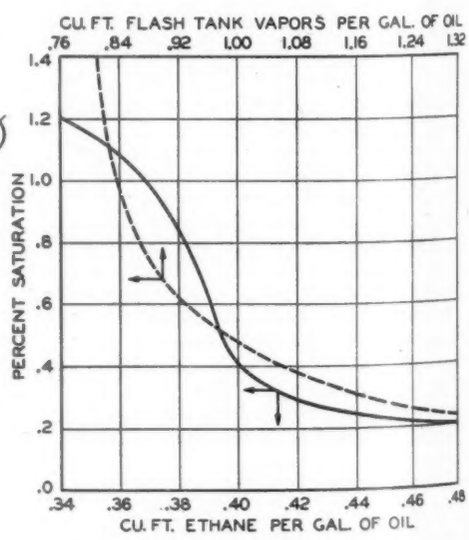


FIG. 6. Effect of changing primary and final stripping stream rates on lean oil presaturation.

proved to be quite successful. Dry distillation may be defined as a process employing hydrocarbon vapors to strip natural gasoline and lighter hydrocarbons from the absorption oil.

The general method of accomplishing this is shown by the simplified flow diagram in Fig. 4.

In this system as well as in other stripping methods, it is desirable to bring the rich oil to the highest possible temperature before introduction into the still. Considerable amount of this heat is transferred to the rich oil by means of conventional oil to oil exchangers. At some point in this oil exchange system a flash drum is placed for the purpose of flashing the lighter hydrocarbons from the rich oil. Care should be taken to place this flash drum at such a point that low molecular weight vapors will be available for the primary stripping in the still. This process feature makes possible the utilization of desirable light stripping vapors which are inherently available in the rich oil stream. The final stripping vapor volume will be substantially reduced when used in conjunction with a primary stripping stream. The flash vapors are preheated as shown in Fig. 4 before entering the still at approximately the midpoint of the stripping section and the preheated final stripping medium is introduced below the bottom tray.

In plants manufacturing propane the final strip vapors are taken from the overhead of the deethanizer column. These ethane vapors, like the primary strip vapors, are heated before being introduced into the still. By using a high purity ethane stream in this operation, the stripped oil saturation may be consistently maintained as low as ¼ of 1 per cent. This degree of saturation is satisfactory in plants recovering 80 per cent of the propane.

The stripping scheme shown by Fig. 5 is similar to the previous system except that it includes the feeding of the excess flash vapors from the flash drum to the rectification section. This feature does not decrease stripping efficiency and reduces the heating and cooling duties in the system. The ratio of primary stripping to excess vapor streams may be 3 to 1; however, the distribution must be determined for each still, depending on the rich oil composition.

Data taken from one operating plant as shown by Fig. 6 establish the optimum ratio of primary to final stripping vapor as 2.6 to 1 for a still operating at 90 psig and 500 F base temperature and using 180 molecular weight oil. The primary stripping vapors are fed at the rate of 1.16 cu ft per gallon of lean oil circulation and the secondary or final strip vapors at the rate of 0.44 cu ft per gallon.

On a tower such as just described, a feed temperature of 500 to 525 F is most desired. This permits the minimum of final strip or agitation vapor; however, the stripping efficiency will be approximately the same if the feed is 450 F and the final strip vapor volume is increased 10 per cent.

Computations and operating experience have proven that 180 molecular weight absorption oil can be stripped to ½ of 1 per cent saturation by use of a primary stripping medium only, with the complete elimination of final or secondary stripping medium.

We have used residue gas as a final stripping medium with success. This is to be avoided if at all possible due to added difficulties in the condensing of the still overhead vapors.

The hydrocarbon stripping operation has certain advantages over steam stripping and some limitations. Operating experience and design data should be employed to determine if a rich oil stream may be satisfactorily stripped by use of hydrocarbon vapors.

Some of the advantages of dry stripping are: (a) elimination of a steam plant, (b) dry system reduces equipment corrosion, (c) control equipment freeze-ups will be materially reduced and (d) in plants that dehydrate the gas before it enters the absorber, propane, or product dehydration may be eliminated.

Disadvantages of hydrocarbon stripping include: (a) a fixed recycle volume of noncondensed vapors and (b) some added difficulty in condensing product vapors.

Underground Storage

Considerable work has been done on the use of underground storage for the storing of butane and propane.

Although this paper is not intended to discuss that phase of the business, we want to mention one operation which our company has used with success.

At our Breckenridge plant in Stephens County, Texas, a cavern was mined out to store 750,000 gal of LPG.

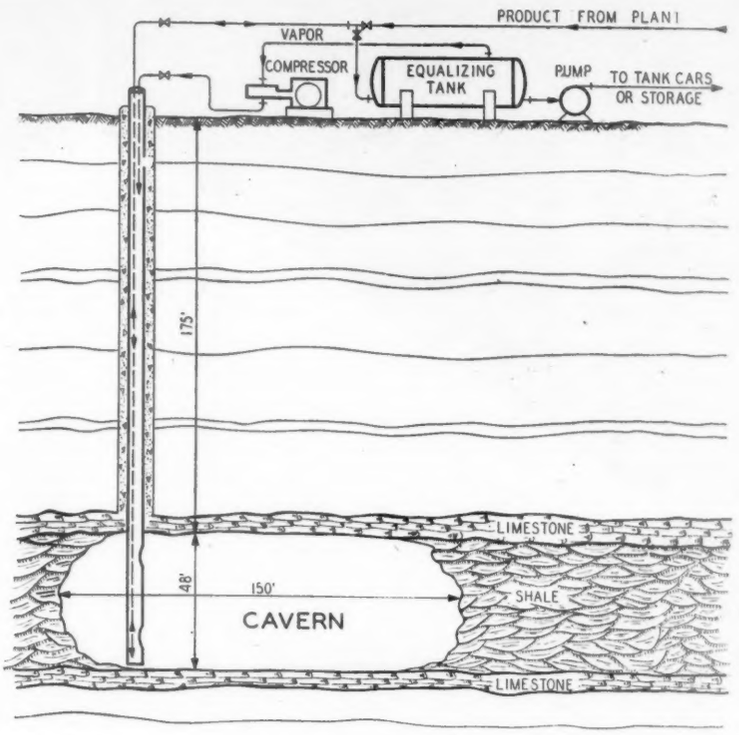


FIG. 7. Schematic arrangement of LPG underground storage system.

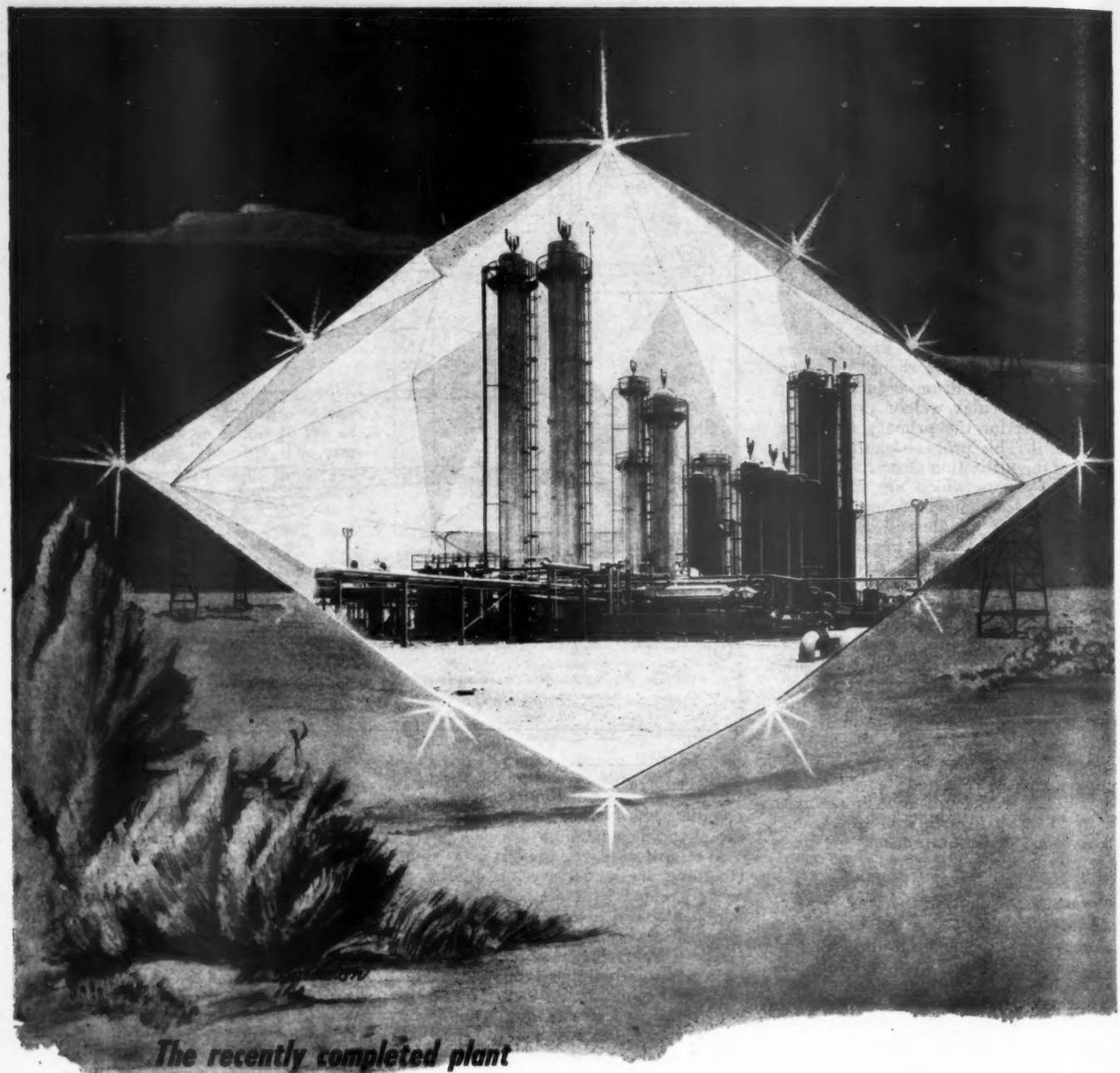
After preliminary core drilling was completed a shaft 4 by 4 ft square was sunk to a depth of 223 ft passing through a lime stone formation at 175 ft and bottomed on another lime stone formation. The shale between these two formations was removed creating a cavern of approximately 100,000 cu ft. This cavern was not completed as a rectangular opening but was in the form of an inverted trapezoid with the width at the top approximately 35 ft and the bottom 18 ft wide.

The complete cavern and piping is shown diagrammatically by Fig. 7.

This cavern has been in use for over a year and has given satisfactory results. After the first filling and evacuation the storage loss was slightly over 5 per cent. The second filling resulted in a loss of about 2½ per cent and we believe that these losses will be negligible on the next evacuation. Evacuation of this cavern is accomplished by the use of recycle vapors through a compressor as shown by Fig. 7. The product purity and color upon evauation did not change at all and was equal to products being stored in steel storage containers. * * *

B-A Refinery Opened

The British American Oil Company Limited, officially opened its enlarged refinery at Moose Jaw, Saskatchewan, Canada, recently. Premier T. C. Douglas of Saskatchewan was the chief speaker at the ceremony. The new refinery, which incorporates the province's first catalytic cracking unit, will "run" approximately 15,000 bbl daily.



The recently completed plant on the

Diamond M Ranch

in Scurry County, West Texas, is the latest of over SEVENTY major Processing Plants designed and constructed by HUDSON during the last ten years.

The HUDSON organization, qualified by years of experience in the successful design, construction and operation of major hydrocarbon processing plants, offers its specialized services for projects in any part of the world.

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Trends in Refinery INSTRUMENTATION

PART 5 — Fabrication and calibration of thermocouples

S. D. ROSS* and J. PROCOPI*

PARTICULARLY in large refineries, fabrication of thermocouple elements from bulk thermocouple wire stock is considered an economical and convenient procedure. As discussed in Part 4 of this article series, the element proper is an expendable part of the complete thermocouple assembly and should be replaced at sufficiently frequent intervals to assure continued accuracy of calibration. If the equipment and skill required to fabricate thermocouples properly is not available, the refinery should purchase fabricated thermocouples, since improper techniques can result in significant errors in temperature measurements.

Certain calibration problems arise when thermocouples are fabricated in the plant, and, additionally, there is the ever-present job of checking installed thermocouples. These subjects of thermocouple fabrication and calibration are considered so vital to the refinery instrument man that they are reviewed in this separate article, even though covered in the literature (see references).

Fabrication of Thermocouples

Fabrication of a thermocouple element merely comprises the joining of the two different thermocouple wires, such as iron and Constantan, with a suitably rigid bond to assure a permanent measuring junction. Often in practice, an additional factor is that the two wires be properly spaced to fit insulators which are used when the element is inserted in the conventional manner in a protecting tube. Many specialized techniques have doubtless been devised by refinery personnel charged with the responsibility of fabricating thermocouples; the techniques described below are those recommended by the Instrument Society of America.[1]

Preparation of Wires for Welding. Assume that the two wires to be joined have been properly selected as a matched pair, as discussed later under "Calibration of Thermocouple Wires." For low temperature applications the junction can be soldered, but welding is recommended by ISA for most installations. Three methods are in common use, namely: (1) gas welding, (2) electric arc welding, and (3) resistance welding.

In preparation for welding, the selected wires are cut to the required lengths from coils of the bulk thermocouple wires. Their lengths are usually determined by the thermocouple assembly in which they are to be used. The cut wires will be curved from having been coiled and must be straightened carefully; hammering or excessive twisting and bending is avoided because this may alter the thermal emf or damage the surface and contribute to short life of the thermocouple.

Where large numbers of thermocouples are being made, a simple jig is helpful for twisting or shaping the ends to be joined. As mentioned previously such a jig, or any manual method, usually must form the junction so as to provide the required spacing for insulators. If insulated wire is being joined, this is not, of course, a requisite.

Gas and Electric Arc Welding. In the case of base metal wires, preparation for gas or electric arc welding varies slightly with the wire size, but comprises essentially (1) cleaning of the wire ends with an abrasive paper and (2) twisting of the cleaned ends together, as illustrated in Fig. 1, with approximately one and a half turns. With 8 and 14 gage base metal wires, the ends are cleaned about one inch back; with smaller sizes (20, 24, and 28 gage), only about one-half inch of the wire end is cleaned.

For noble metal wires (Platinum, Rhodium-Platinum) only electric arc welding, by a method to be described, is recommended. In the preparation of these wires for welding, extra care should be taken to avoid cold working and contamination by dirt, oil, perspiration, and the like. No surface preparation is required; the wires are recommended to be formed as shown in Fig. 2.

Resistance Welding. This method is recommended only for larger sized wires (8 and 14 gage) and is not recommended for Copper-Constantan or Platinum, Rhodium-Platinum thermocouples. Preparation involves cleaning of the wire ends for about one-inch back and shaping these ends so that they come in contact, as shown in Fig. 3.

Welding Methods. Table 1 indexes the ISA recommended methods of welding with respect to the type and size of thermocouple wire. Below is a summary of these methods. Where flux is required,

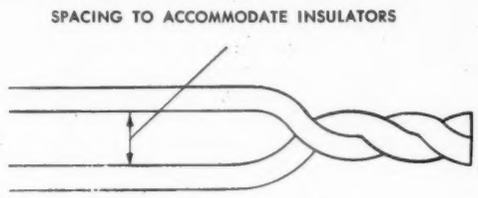

FIG. 1. Method of twisting wires for welding.

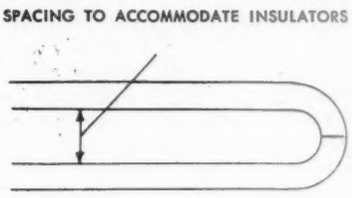

FIG. 2. Method of forming wires for butt-welding. (Recommended method for noble metal wires to be electric arc welded, but also employed for base metal wires).

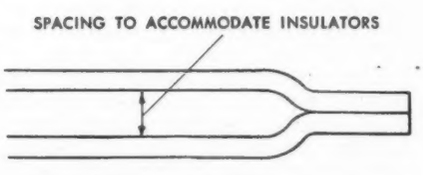

FIG. 3. Method of forming base metal thermocouples for resistance welding.

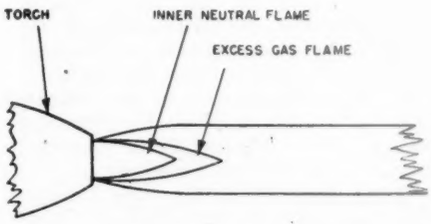

FIG. 4. Character of proper flame from torch for gas welding.

*Brown Instrument Division of Minneapolis-Honeywell Regulator Company.

EXCLUSIVE

powdered boric acid is generally satisfactory.

Gas Welding. For gas welding of base metal thermocouples an oxy-acetylene flame is generally used.[2] The character of the flame (Fig. 4) is one of the most important considerations. An oxidizing flame should never be used. Such a flame is injurious to the metals and can not result in a good weld. The weld should be made, if possible, on the first attempt; continued heating at welding temperatures results in a poor weld.

The recommended procedure in gas welding is as follows:

(1) Direct tip of inner (neutral) flame at ends of twisted wires and heat bright red.

(2) Immediately dip heated ends into flux.

(3) Again direct tip of inner flame at ends of twisted wires. Because one wire melts at a lower temperature (see Table 1) manipulate wires in flame until both wires reach their melting points at about same time. When both wires have melted, turn wires in flame until both melts flow together and form a ball at wire ends.

(4) Remove remaining flux by dipping into water.

(5) Inspect weld with low power magnifying glass to disclose evidence that metal has been burned; this is detected by presence of small pits on surface of weld.

If a good weld is not obtained and a shorter thermocouple element can be used, cut off the ends and repeat the procedure. Otherwise, discard the thermocouple and charge it up to experience.

Electric Arc Welding. Two types of electric arc welding are employed, namely: (1) *single carbon electrode*, and (2) *double carbon electrode*. In the single electrode method, an electric arc is drawn between the junction to be welded and a carbon electrode; the carbon electrode is placed in contact with the junction and immediately withdrawn (with current on) causing a high temperature arc which fuses the junction. In the double electrode method, the principle is similar, except that the electric arc is drawn between two carbon electrodes with the junction to be welded between them.

As will be noted from Table 1, the single electrode method is not recommended for noble metal thermocouples, nor for small sized base metal thermocouples. With either method the following equipment is required: (1) a source of electric current, (2) a suitable rheostat for regulating the current, (3) one or two carbon electrodes with insulated holders, and (4) a clamp or vise to hold the wires (acts as other terminal also for single electrode method). The electrodes should be pure soft carbon. Either alternating or direct current can be used, although d-c is preferred in the single electrode method.

The quicker the weld is made, the better. Too much current, however, may burn the metals. For an 8-gage thermocouple, the voltage across the electrodes should be adjusted to approximately 30 to 45 volts; proportionately lower voltages should be used for smaller sizes of wire. A small bead should be produced on the ends of the wire; no bridged welds or gaps of metal between the wires should be obtained because these are structurally weak.

TABLE 1. ISA recommended methods for welding thermocouples.

Thermocouple		Method			
			Electric Arc		
Kind	Size, B & S Ga.	Gas	Single Electrode	Double Electrode	Resistance
*Copper-	8,14	Yes	Yes	Yes	NR
Constantan	20,24,28		NR		
*Iron	8,14	Yes	Yes	Yes	Yes
Constantan	20,24,28		NR		NR
Chromel-	8,14	Yes	Yes	Yes	Yes
*Alumel†	20,24,28		NR		NR
Platinum, Rhodium- *Platinum	All	NR	NR	Yes	NR

* Asterisk denotes lower melting point material.
† Trade mark registered Hoskins Corporation.
NR—Not recommended.

Procedure for the single electrode method essentially comprises the following steps:

(1) Dip ends of wires to be joined into water and then into flux.

(2) Clamp wires in vise with ends pointing upward; avoid injury to wires. Positive lead (if d-c is used) is connected to vise.

(3) Carbon electrode, connected to negative lead, is brought in contact with junction and withdrawn to draw arc. Correct arc has gap about 1/16 of an inch, which minimizes oxidation and nitrogen absorption.

Procedure for double electrode method is as follows:

(1) Dip ends of wires into water and then into flux.

(2) Clamp wires in vise with ends pointing upward.

(3) Bring two carbon electrodes together and separate to draw an arc.

(4) Move electrodes to bring arc into contact with junction to be welded.

Furrh[7] outlines an immersion technique for electric arc welding of thermocouples which he claims simplifies the procedure for those not familiar with welding techniques. His method involves the following steps:

(1) Fill a small glass beaker approximately two-thirds full of mercury (preferably triple-distilled).

(2) Pour one-inch of transformer or slidewire immersion oil on top of the mercury.

(3) Ground electric arc welder to mercury.

(4) Secure both wires of thermocouple in electrode holder and dip twisted end into mercury. At the moment of contact the wires will be fused in a clean ball or "bead" weld.

The oil keeps the thermocouple from heating above the weld, and keeps air from coming in contact with the welding arc, therefore it prevents oxidation.

Electric Resistance Welding. In this method, which is limited primarily to large sized Iron-Constantan and Chromel-Alumel thermocouples, the contact resistance between the two wires at the junction, and the resistance of the wires themselves, cause heat to be generated when sufficient electric current is passed through them. In this way, the two wires are fused together.

Procedure for this method simply comprises:

(1) Place junction between electrodes of a resistance welder.

(2) Apply pressure and current for necessary time to produce a good weld. Amount of pressure, time, and current necessary varies with available welding equipment, size of wires, and thermocouple wire material. Too great a pressure reduces resistance between wires and produces weld that looks good but is fused only around edges.

Calibration of Thermocouple Wires

When a thermocouple is to be fabricated in the field, mention has been made of the need for "matched pairs" of wires. A thermocouple fabricated from wires obtained from different sources, or even from the same source at different times, may not conform to the calibration tables for the thermocouple within the required limit of error. For example, the chemical composition of iron wire varies slightly from melt to melt. Consequently, to obtain an Iron-Constantan thermocouple whose accuracy conforms to specifications, the calibration of the Constantan wire must be matched according to that of the iron wire. In addition, the thermal emf characteristics of the Constantan for use with iron wire may differ from those of Constantan to be combined with copper for Copper-Constantan thermocouples.

Matching Thermocouple Wires. Stocks of bulk thermocouple wire (in coils) can be properly paired by comparison of the emf developed by samples of each coil against a reference standard, usually platinum. In practice, however, base metal wire is compared against a *standard base metal wire* of the same material as that being tested—the standard wire having been calibrated against platinum.

The method of calibration, described below, essentially comprises formation of a thermocouple with the wire to be tested and the working standard, then measurement of the small emf developed at selected temperatures. The measured

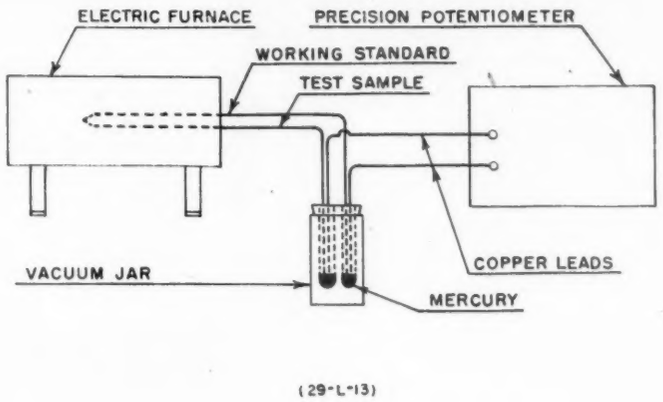

FIG. 5. Circuit for testing thermocouple materials.

emf is a measure of the dissimilarity of the two elements; to determine the emf of the sample base metal wire versus platinum, the small measured emf difference between the sample and the standard is added algebraically to the large emf of the working standard at the specific temperature (as obtained from calibration tables).

Iron, copper, and Chromel are positive with respect to platinum, while Constantan and Alumel are negative. This must be considered in the algebraic addition of individual emfs of the two wires which are to comprise the thermocouple. For example, an iron wire might have an emf of +6.60 mv at 900 F and a Constantan wire, an emf of —19.81 mv at this same temperature. The emf of this thermocouple combination would be 26.41.

Example of Wire Matching. Assume that measured emfs have been made of three samples of iron wire and three samples of Constantan wire at 900 F. Calculated with respect to platinum, assume that the emf values are as follows:

Iron, mv	*Constantan*, mv
(a) 6.56	(d) 19.80
(b) 6.62	(e) 19.77
(c) 6.60	(f) 19.86

From a temperature-emf table for an Iron-Constantan thermocouple at 900 F, the standard emf value is found to be 26.41 mv. The wire samples are then matched so that their total emf most nearly approximates this value, as follows:

(a) + (f) = 26.42
(b) + (e) = 26.49
(c) + (d) = 26.40

If the combined emf of the iron and Constantan samples does not closely approximate the value given in the table, it is probable that the particular coil of Constantan should be used for Copper-Constantan thermocouples. For example, at 600 F the total emf of iron and Constantan should be nearly 17.16, while that for copper and Constantan at the same temperature should be about 15.77.

Equipment Required. Following is the recommended equipment for measuring the emf difference between the wire sample and the calibration standard:

(1) *Furnace for heating the thermocouple wires.* This should have a temperture range sufficient to cover the range of wires to be tested. A tubular type of furnace is described in NBS Research Paper RP-768 for this purpose.[4] An ordinary, electrically-heated tubular or muffle furnace, however, is entirely adequate. The furnace should be equipped with a rheostat or other means for making voltage adjustments since on-off control results in excessive cycling of the furnace temperature.

(2) *Precision laboratory potentiometer and galvanometer*, such as the Rubicon Type B (Catalog 2780) instrument, and the Rubicon Spotlight Galvanometer (Catalog 3411).

(3) *Equipment to maintain reference junction temperature at a constant value.* For the usual reference junction temperature of 32 F, this can be done by means of an ice bath in a vacuum jar. The reference junctions of the test sample and standard are immersed in separate test tubes, each containing a small amount of mercury; the test tubes are then inserted in a mixture of shaved ice and water in the vacuum jar, as shown in Fig. 5.

(4) *Calibrated working standards.* The accepted practice for obtaining such standards is to select a coil of each material to be calibrated, test it for homogeneity,* and submit one or more samples to the National Bureau of Standards for calibration against platinum.

Test Procedure

Tests of sample versus standard are made as follows:

(1) Cut length of sample and length of working standard (three feet is a convenient length).

(2) Weld one end of sample and one end of standard to form measuring junction, as described for welding of thermocouples earlier in this article.

(3) Insert "thermocouple" in furnace and connect to potentiometer and vacuum jar, as shown in Fig. 5. (Note that copper leads are used to make connections from ice bath to potentiometer.)

(4) Heat furnace to checking temperature, allowing sufficient time for equilibrium to be established; read temperature and emf output, noting if it is positive or negative. (Note: As the emf difference between the sample and standard rarely exceeds 0.3 mv per degree Fahrenheit, precise measurement of the junction temperature is not necessary; experience has shown that if the temperature of the junction is measured within 20 F, and in some instances, 40 or 50 F, no appreciable error will result. In general, the accuracy of the test is limited only by the accuracy of the standard).

If desired, several samples from various coils of the same thermocouple material can be welded to a single standard, and tested at the same time. The reference junction of each sample and that of the standard can then be inserted in separate test tubes in the ice bath and the copper leads from each junction connected to the potentiometer through a selector switch, so that individual measurement can be made of the emf developed between each sample and the standard. (The selector switch and separate copper leads for each test sample may be omitted; one copper lead can then be consecutively inserted in the test tube of each sample and individual readings made.)

Precautions to be taken in the test procedure are as follows:

(1) The inside of the ice bath test tubes should be kept clean and dry. A trace of moisture or dirt at the bottom of the tubes may form a galvanic cell that can seriously affect the accuracy of tests.

(2) The copper leads should be insulated from the thermocouple wires, except where they make contact in the mercury pools.

(3) Because slight changes in calibration occur when base metal wires are subjected to high temperatures, the sample and standard should not be used more than once.

(4) For the same reason (3), the emf should be measured at low temperatures first and then in steps toward higher temperatures. Measurements should

*A homogenous thermocouple wire is one having uniform physical and chemical composition throughout its length. The homogeneity of a coil can be tested by cutting samples from various parts of the coil, welding the ends together, and measuring the emf between samples. If the emf developed between each pair of wires does not exceed approximately 10 microvolts at 1200 F, any length of wire from the coil can be considered sufficiently uniform for use as a working standard. (NOTE: It is rarely possible to select a coil of Chromel wire to a uniformity of 10 mv at 1200 F; when this wire is to be tested, it is suggested that several coils be checked and that the most uniform be selected.)

never progress in the opposite direction.

Checking Installed Thermocouples

When received from the supplier, or when fabricated from matched pairs of wires, thermocouples are expected to follow very closely the established temperature-emf relationship. During their period of service, however, the thermal emf characteristics of a thermocouple change to a degree varying widely with the nature of the application. In order that reliable temperature measurement and control can be assured, therefore, the refinery must establish a routine for checking installed thermocouples.

Although protecting tubes greatly retard deterioration of thermocouples, they can not prevent it entirely. As a general rule, thermocouples subjected to high temperatures and/or contaminating atmospheres deteriorate more quickly and should be tested at relatively close intervals. In some refinery applications where the temperature and type of atmosphere remain fairly constant, the rate of deterioration can be determined from a few tests and a replacement rate established. Usually, however, these factors vary unpredictably and arbitrary schedule must be established — once a week, if extreme accuracy is desired, or once a month or once every three months, as conditions may warrant.

Calibration Changes of Used Thermocouples. The extent and direction of the temperature error depends upon (1) the type of thermocouple, (2) the temperature and atmosphere to which it is subjected, and (3) the length of time it has been installed. The National Bureau of Standards has done considerable work in investigating the stability of base metal thermocouples under oxidizing conditions, as published in Research Paper RP-1278.

For a given reference junction temperature, the emf developed by a new homogeneous thermocouple is dependent only upon the type of thermocouple and the temperature of the measuring junction. As a result of contamination and deterioration, however, a used thermocouple is not homogeneous; hence, the emf developed is dependent as well upon history of the temperature distribution along the non-homogeneous portion of the wires. If this portion of the thermocouple is entirely within a region of uniform temperature, the emf produced will be unaffected and will correspond to the original calibration of the thermocouple. Usually, however, the non-homogeneity occurs in a region of temperature gradients along the wire.

For this reason, *it is recommended that the used thermocouple be left in place when checked,* and *not* removed for testing in a laboratory furnace where it is practically impossible to duplicate the temperature gradients of the actual installation. It is advisable to test a used thermocouple under the same conditions and in the same installation where it is normally used.

Test Procedure. Basically, checking of the used thermocouple in its installed position involves the comparison of its emf output with a standard thermocouple whose measuring junction is brought in close proximity to that of the installed thermocouple. It is common practice to use as a standard a thermocouple of the same type and size as the thermocouple to be tested. A new thermocouple whose calibration has been determined by comparison with a primary standard, or directly against platinum, may be used as a reference standard.

The selected standard should be tagged accordingly and reserved for checking purposes. Because its original emf characteristics, like that of any used thermocouple, will change gradually, it is recommended that such a standard be tested at intervals, depending upon the frequency of its use, and be replaced when it is beyond the desired limits of accuracy.

There are several methods for checking installed thermocouples and the desirable method depends upon the type of installation. Accurate testing requires essentially constant temperature during the test, although this is not always possible. The methods are given below in the order in which they are recommended:[6]

(1) *Insert a reference standard in the same protecting tube as the used thermocouple,* if the size of the protecting tube permits. Each thermocouple can be connected in turn to a portable potentiometer through a selector switch and the emf of each compared. Better still, it is recommended that a separate checking instrument be used with the checking thermocouple, to permit checking of the service instrument, as well as of the service thermocouple.[5]

(2) *Install a reference standard adjacent to the fixed thermocouple.* Drill a hole as close as possible to the installed thermocouple and insert the standard in such a manner that the ends of the two protecting tubes are as close together as possible. (To insure a fair comparison, the standard thermocouple should be of the same size wire as the couple being checked, and should have the same type and size protecting tube). Compare emf outputs of the two thermocouples as in Method No. 1.

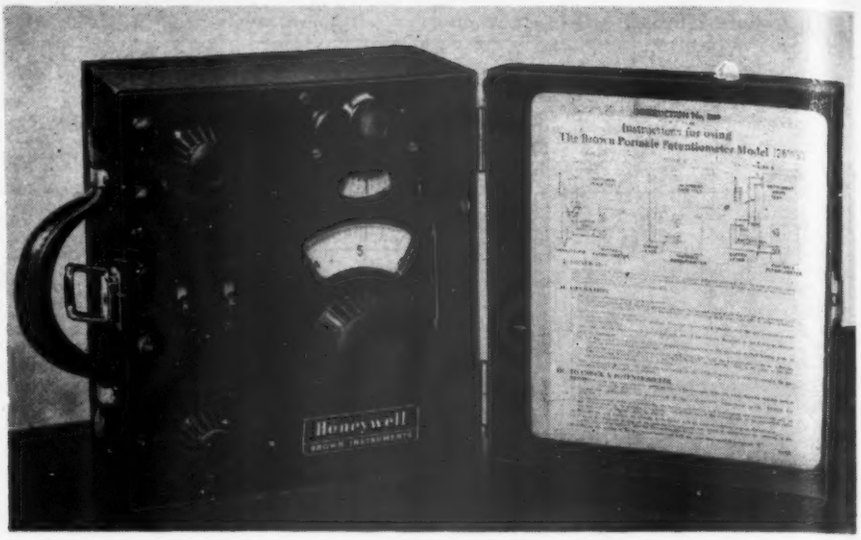

FIG. 6. View of portable potentiometer useful for checking used thermocouples.

Note: Large temperature gradients can exist in the process equipment where the thermocouple is installed and even points physically close together may be at surprisingly different temperatures. For this reason ISA does not recommend this method of checking.[5]

(3) *Compare readings of successive installations of used and reference thermocouples.* Test the used thermocouple first by reading the emf developed at the operating temperature. Remove the used thermocouple from its protecting tube and replace it with the reference standard. (Note that the standard should always be inserted in the protecting tube to the same depth as the used thermocouple). Insert the assembly to the same depth as the one tested (if the protecting tube is removed at all), *wait for the reference thermocouple to come to equilibrium,* then read the emf developed and compare it to that of the used thermocouple.

Method No. 3 is generally less preferable than the others because it requires that the process temperature remain constant for a longer period. This may not be feasible for the process at hand.

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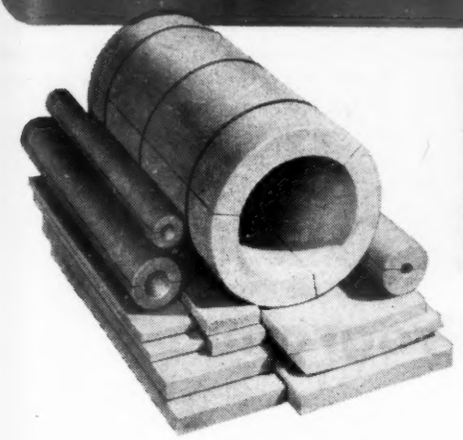
Part 6 of this series of articles will be published soon.

Pattern for the Future...



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Kaylo Heat Insulation, a hydrous calcium silicate, has high insulating value over a wide temperature range. It is *effective* up to 1200°F.—thus eliminating the need for combination coverings in nearly all operating conditions.

In addition, Kaylo Heat Insulation has these excellent physical characteristics: it is insoluble in water and incombustible. It has dimensional stability . . . high strength . . . light weight — properties vital to a superior heat insulation.

Its ease of handling, cutting and fitting simplifies application—saves time on the job. With these important extra advantages, *at no extra cost*, little wonder that leading refiners are switching to Kaylo Heat Insulation.

For complete details on Kaylo Heat Insulation, write Dept. N-254, Owens-Illinois Glass Company, Kaylo Division, Toledo 1, Ohio.

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The safety engineer takes time out to discuss some safe welding practices with plant maintenance personnel.

A valve and piping arrangement calls for a conference between the safety engineer, superintendent, foreman, and operator.

The plant operators discuss the location of a sidewalk with the safety engineer which will provide easy and safe access to plant operating units.

Natural Gasoline Plants

A Safety Inspection Program

Regular inspection routine, follow-up on recommendations made, and liaison between inspector and personnel pays safety dividends

DON ATTAWAY*

Safety man and plant operator have one-the-spot conference about location of a light for safer night operation.

THE most ardent supporters of the belief that man-failure is the predominant accident cause are, nevertheless, firmly convinced that mechanical guarding and the correction of unsafe physical conditions is a fundamental and first requirement of a complete safety program. Safety engineers experienced in natural gasoline plant and refinery operations generally act on the theory that safety begins with the design of the plant and continues through the application of safe tools, equipment, processes, practices, and environment.

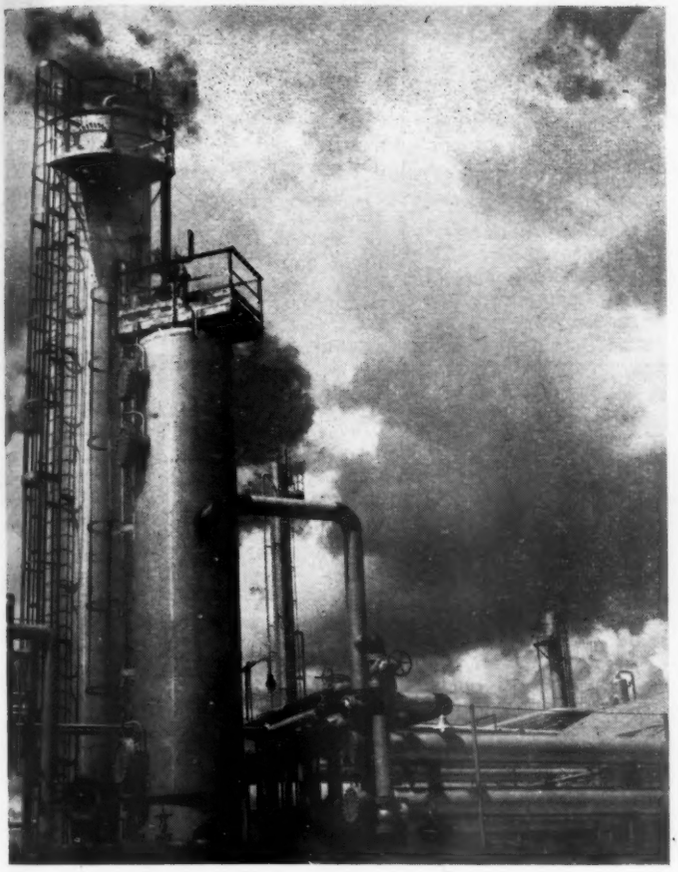
This attitude is not inconsistent with actual statistics, which show that although unsafe acts and man-failure "causes" most of the accidents, a program of engineering revision, mechanical guarding, and physical corrections is most valuable in "preventing" accidents.

Safety engineers are quick to realize, too, that although less than 30 per cent of all industrial accidents are directly due to unsafe mechanical and physical conditions, the severity rate for such accidents is extremely high. In short, this means that accidents caused by unsafe acts are more numerous, but seldom as deadly and costly as those due to unsafe conditions. For example, the failure of a high pressure vessel due to an unsafe physical or mechanical condition can result in a fire or explosion that may cause serious property damage and take numerous lives, whereas the unsafe act of an employee, such as jumping across a walkway, may result in a fall that does no property damage and may or may not injure the man.

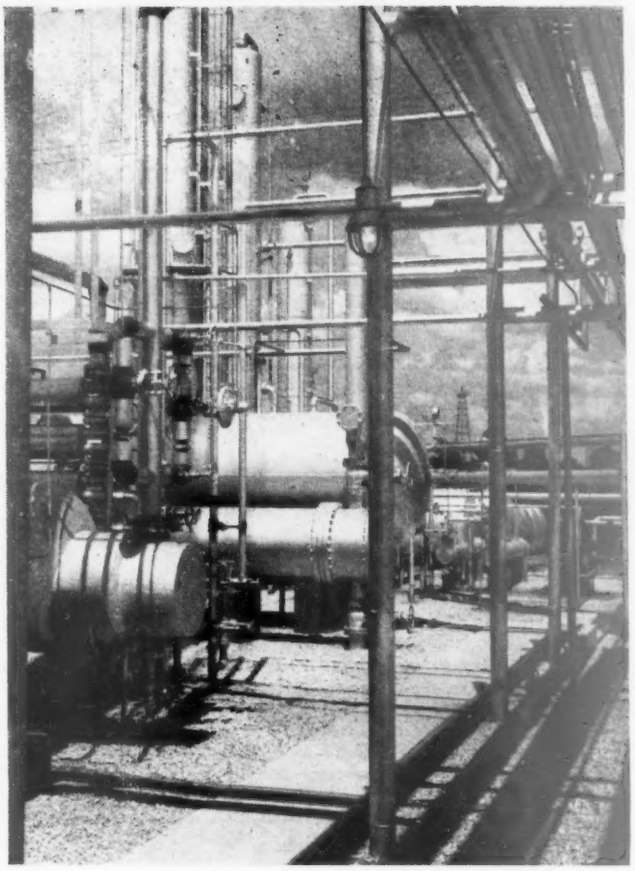
In view of these conclusions, the management of the company represented by the writer, was convinced that a program of regular plant safety inspections could be used to supplement their accident prevention campaign. Consequently, a study was made of the project and a mutual agreement reached between the workmen and supervisors calling for

*Safety engineer, Arkansas Fuel Oil Company.

EXCLUSIVE



Fully enclosed ladders on processing vessels is a mark of safety in any plant.



Adequate and properly located sidewalks are a vital safety factor in any natural gasoline plant.

quarterly joint inspections of facilities and physical condition of plants and a routine of correction established.

Although safety was given serious consideration in the design and layout of each plant in their original construction it was recognized that later expansion, modification, and plant re-vamping often produced physical hazards not easily identified on drafting boards or blue prints. These unsafe conditions usually did not reveal themselves until actual operations pointed out the hazard or the experienced eyes of the safety engineer or plant supervisors spotted the danger.

The safety inspection program is simple in plan. Once each three months the department safety engineer advises the plant superintendent and personnel by written notice of a regular inspection schedule giving date and time that each plant will be inspected. Upon the safety man's arrival at the plant, a conference with the superintendent is held and a review of the last inspection report made. Items listed as unsafe are checked for any correction made since the last inspection. Often unusual hazards call for extensive study and research in order to determine a satisfactory corrective measure. Consideration must be given to the economics of the problem as complete plant reconstruction or extensive plant alterations are out of the question. The expense of each guard, piping change, fitting relocation must be justified and in keeping with the benefits derived.

Fortunately most corrective measures for unsafe mechanical and physical hazards are relatively simple, but often acute and complicated problems involving extensive plant equipment must be solved. Usually these require corrective measures to a degree. This may or may not mean the complete elimination of the hazard, but the reduction of its severity and potential danger to a point of relative safety.

After the safety engineer and the plant superintendent have completed their review conference, a unit by unit inspection of each installation in the plant is made in company with a member of the workman's committee or operating personnel. It has been found that the man on the job is not hesitant to point out or call attention to any condition that jeopardizes the operation of the plant equipment or his own personal safety. Especially when the safety man is present to interpret and evaluate his complaint.

A remarkable degree of cooperation developed as a result of these on the spot conferences between workmen and supervisors. A commendable pride of workmanship in the employee resulted when his unit was found to be clean, neat, and physically safe. On the other hand when a questionable condition developed, it was often the employee in person who suggested the remedy or corrective measure that best eliminated the hazard. But as might be suspected, quite a few of the plant hazards are detected by the safety engineer. This is easily explained by the fact that there are many dangers unseen and unsuspected that are beyond the worker's knowledge and skill, which by training and experience the safety man is able to locate. Furthermore, the old saying that familiarity breeds contempt is quite appropriate in many cases as a worker may realize an unsafe condition on his job, but by working day after day in its presence and by constant and continuous awareness of its existance become so accustomed to its location that he no longer considers it a hazard. Of course, this is a fallacy on his part and the type of hazard that the safety man is best qualified to locate and correct.

A written report is made of all unsafe conditions noted during the tour of inspection. The original is forwarded to the head of the department for his information and consideration. Copies are furnished the plant superintendent, workman's committee, and other interested parties. From these reports, conditions are analyzed and evaluated and corrective measures outlined and inaugurated. In cases of complicated or extensive hazards, the safety engineer usually photographs the location and equipment for further study. Copies of these photos enable the department head to better understand the problem.

The results of this plant safety inspection program has been threefold. First of all, a tremendous reduction in accidents has resulted. As an example, one of the company's largest plants employing some 60 persons had never been

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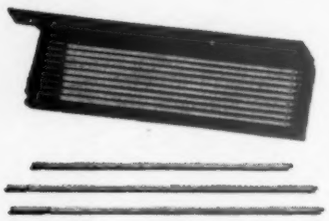

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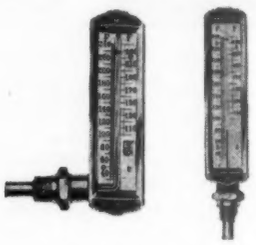

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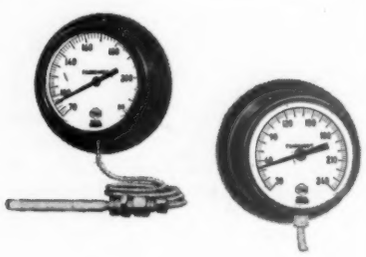

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WESTON *Temperature Instruments*

— TO INDICATE — RECORD — CONTROL

9413

able to work 18 consecutive months without a lost time accident. During the past few years, this plant has undergone a more or less constant program of expansion and enlargement involving extensive construction. Early in 1951, the operating and maintenance crews entered upon a program of accident prevention that centered around hazard elimination and constant good housekeeping. At present this plant has worked more than 250,000 man hours over a 20 month period without a single lost time accident.

The second benefit was a valuable improvement in plant appearance. Piping that was formerly a stumbling and striking hazard was relocated. Sidewalks were installed for convenient access to operating units. Plant lighting was relocated and distributed for maximum benefit. Process areas were filled with white chat and a paint program completed. Guards, ladders, tool boards, and fire houses were installed for safety and convenience. As a result orderly and attractive appearance came to the entire plant.

The third and major result of the program was a marked improvement in employee morale. Each and every man exerted greater effort to keep his area clean and safe. Repair crews gave more attention to clean-up after maintenance work and a general pride in workmanship developed. Housekeeping reached a new high. Care and use of tools and material improved considerably and as a consequence a greater efficiency was reflected in all operations.

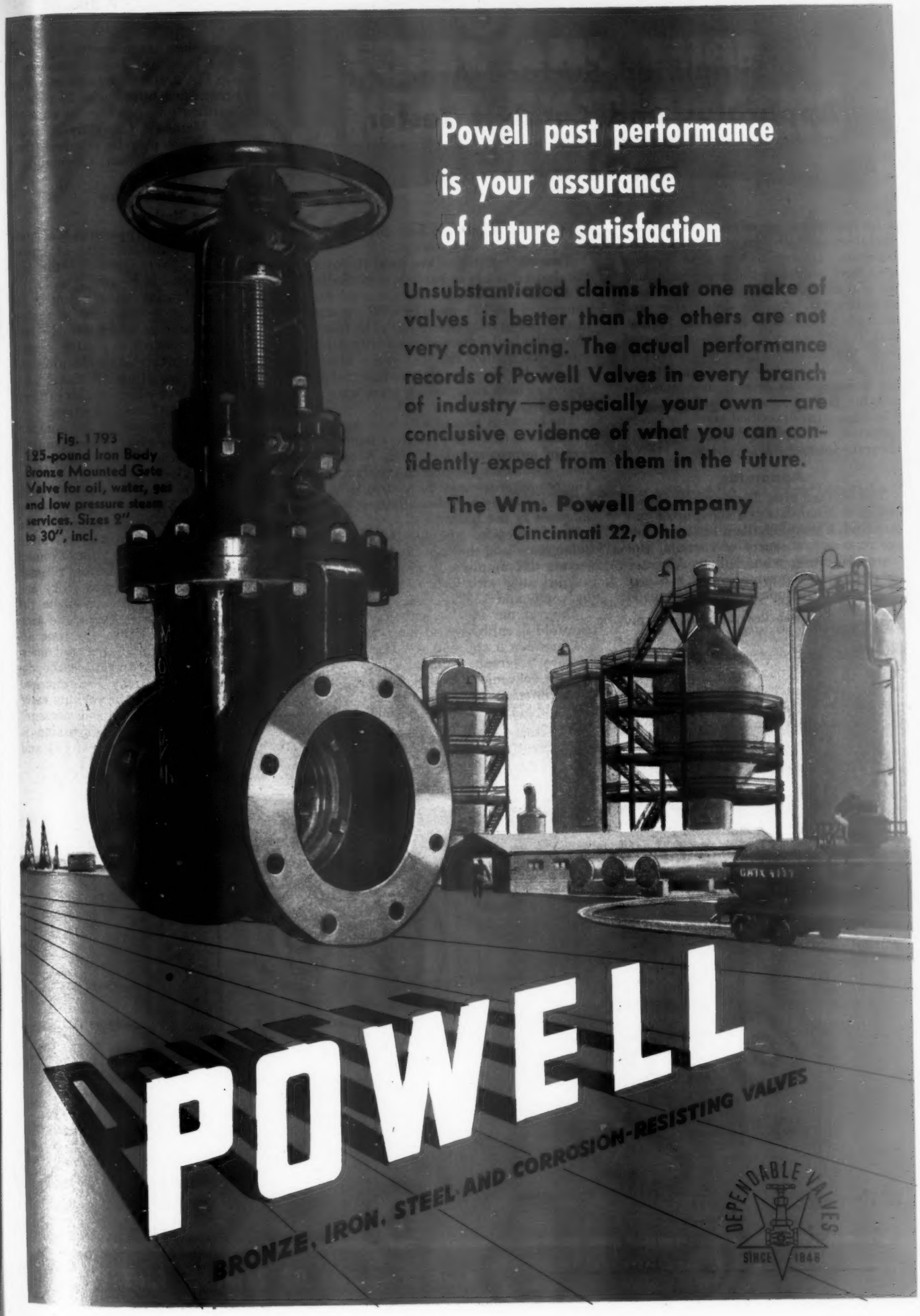
There can be no doubt that the elimination of unsafe conditions in a natural gasoline plant pays big dividends. Nor can there be any question of a method for obtaining safe and efficient operations. When men are eternally vigilant, accidents decline or disappear. When an incentive is present to encourage employees in safe practices, maintaining interest can easily be accomplished by a regular plant safety inspection schedule. ★ ★ ★

Unit for Recording Sulfur in Operation

A unit that will recover up to 55 tons of elemental sulfur daily from waste refinery gases went into operation recently at the Houston, Texas, plant of the Shell Chemical Corporation, plant manager B. M. Downey announced. Construction of the plant was a move aimed at alleviating the critical shortage of sulfur and its most important compound, sulfuric acid.

The new sulfur recovery unit, certified by the government as a necessary defense project, was constructed by the Ralph M. Parsons Company of Los Angeles. In the recovery process hydrogen sulfide as contained in waste refinery gases will be catalytically converted to 99½ per cent pure sulfur at an annual rate in excess of 13,000 tons.

An unusual feature of the unit is that the sulfur will be stored in molten form in an underground tanks at a temperature of 300 F.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A Simplified Surface Area Apparatus and Catalyst Tester

DAN E. SMITH*

THE increasing use of catalysts in plant operations and the successful correlation between catalyst activity and surface area have produced the need for a simple and accurate method of surface area measurement. As the apparatus and methods described by Brunauer, Emmet, and Teller† are somewhat complicated and the accompanying calculations tedious and time consuming, an attempt has been made to develop an apparatus suitable for use in a control laboratory. The apparatus described herein is easily operated, inexpensive, and sufficiently accurate for control purposes.

Apparatus

The surface area apparatus is shown in Fig. 1. It consists of a manometer and manifold, a sample bulb, a nitrogen storage reservoir, a source of vacuum, and sources of nitrogen and helium. A heater for degassing the sample, and a dewar flask are also included. The apparatus is mounted on a suitable base for convenient portability and storage.

Two sizes of bulbs are used to cover the desired range of surface area. Bulbs of 0.5 ml and 0.2 ml size are used for ranges of 50-125 and 100-300 square meters per gram, respectively. The tubes above the bulbs are equipped with filler tubes that reduce the free space above the sample. They are glass rods, or tubes closed at both ends, which leave only a small annular space.

The heater is wound with wire having a resistance that will produce a temperature of approximately 300 C. A resistance of 80 ohms has proved satisfactory. The temperature may be controlled by a rheostat or by a Fenwal thermoswitch mounted in the heater.

The stopcocks are lubricated with Cellogrease and the spherical joint connecting the sample bulb to the manifold is lubricated with Cenco vacuum sealing compound 15521A.

The volume in the manometer and manifold is calibrated at intervals of 50 mm between 0 and 650 mm Hg against a known reference volume. Fig. 3 illustrates a convenient method for plotting the calibration data. The volume of the reservoir (7) is calibrated with mercury.

The nitrogen thermometer for measuring the purity of liquid nitrogen is shown in Fig. 2. It is evacuated and filled with prepurified nitrogen to 25 psig.

Prepurified nitrogen may be obtained from the Matheson Company at Joliet, Illinois. Helium may be obtained from Ohio Chemical Company, Cleveland.

Procedure

One-Point Method.

1. Calibration of Apparatus. Calibrate the apparatus with samples of known surface area (Note 1) using the procedure described in Section 3, A,(2). A separate calibration must be made for each tube. Fig. 4 illustrates a typical calibration curve in which the observed equilibrium pressure is plotted against the observed surface area. An alternate method is the use of an additional scale on the manometer which enables the operator to read surface area direct.

Note 1. The values for the standard samples may be obtained by using the two-point method described in Section 3, B,(1).

2. Procedure. Weigh the sample bulb, filler tube, and 5-10 mg of glass wool to 0.1 mg. Fill the bulb with sample to the top of the rounded portion, and insert the glass wool and filler tube. Connect the sample tube to the manifold through a spherical joint, open valves (1) and (2) to apply vacuum, and place the heater around the tube. Degas the sample one-half to two hours, the time depending on the surface area and moisture content. The progress of the degassing procedure may be checked periodically by closing the vacuum valve (2) and noting any change in pressure on the manometer. After degassing is complete, close valves (1) and (2) and

*Phillips Petroleum Company, Research Division, Bartlesville, Oklahoma.

†S. Brunauer and P. H. Emmet, JACS 57, 1754 (1935).

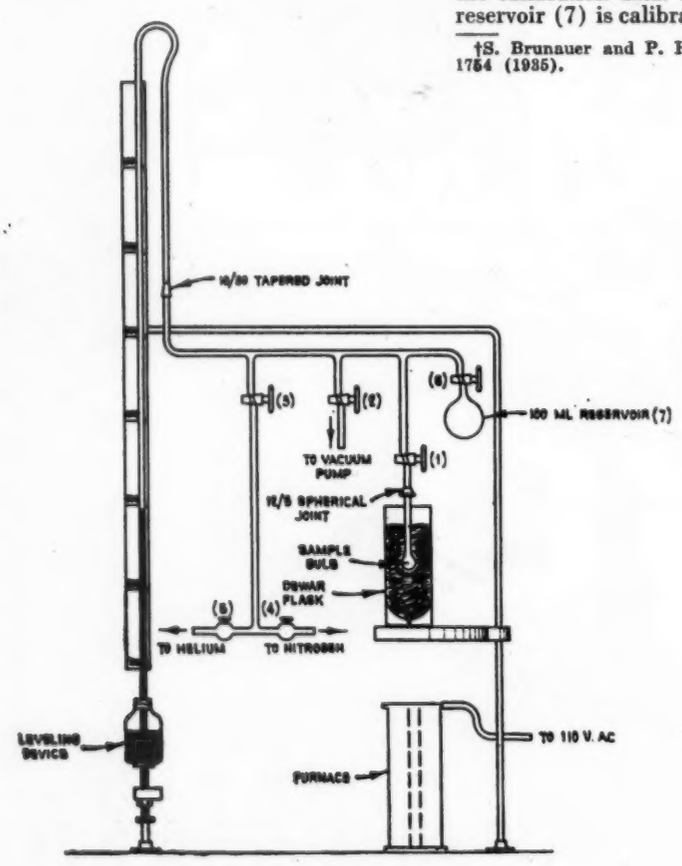

FIG. 1. Catalyst tester.

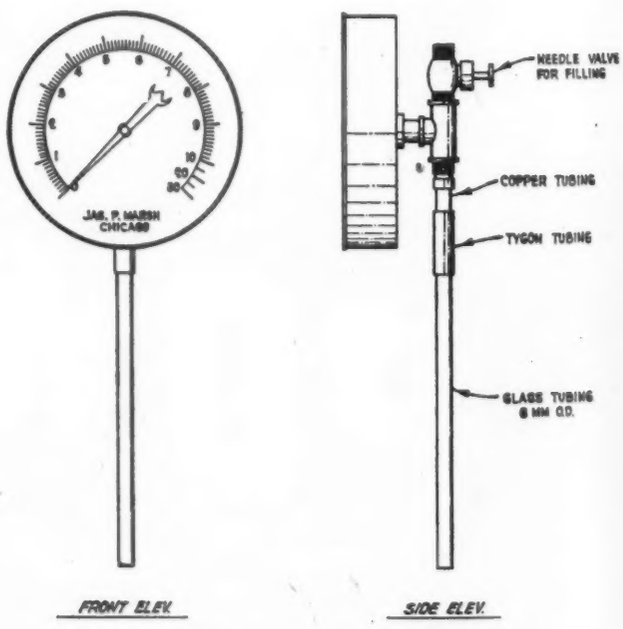

FIG. 2. Nitrogen thermometer.

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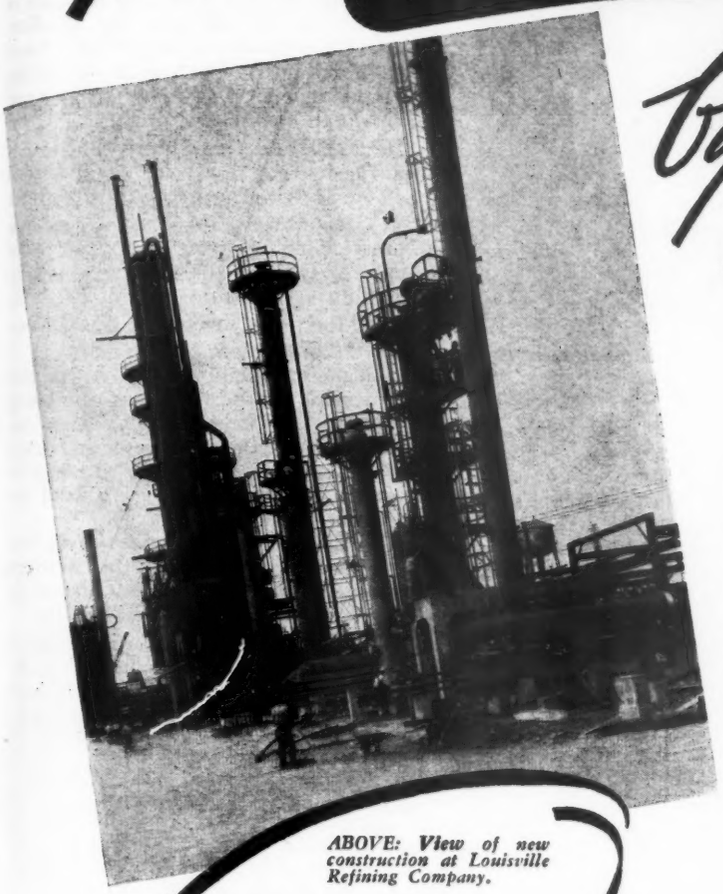

ABOVE: View of new construction at Louisville Refining Company.

BELOW: Some of the many Shell and Tube Exchangers.

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The new plant uses Vogt Shell and Tube Heat Exchangers exclusively and they make a significant contribution to the efficient and economic operations of this progressively modern refinery.

Vogt Shell and Tube Heat Exchangers are available in many different types, with fixed or removable tube bundles, to meet the special problem and specific operating conditions of each installation. They are constructed from carbon and special steels to meet every temperature, pressure, or vacuum service requirement.

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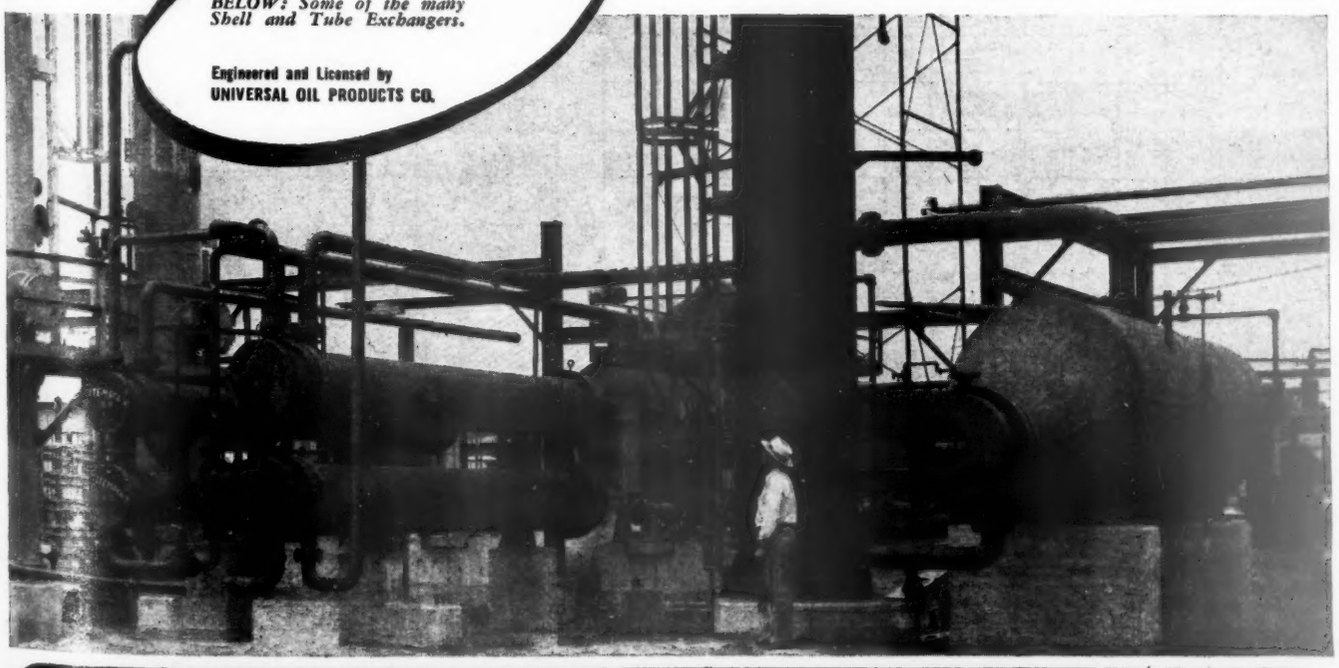

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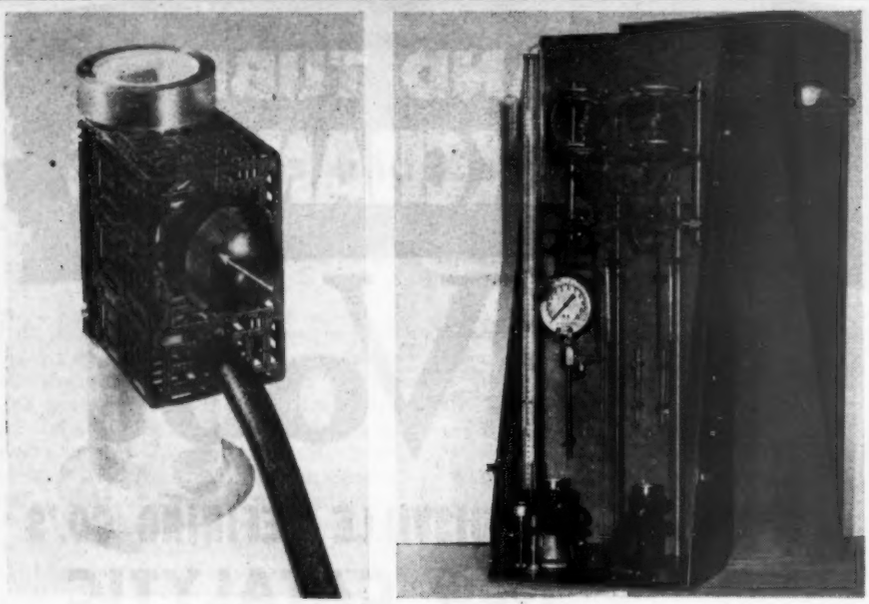

Furnace for degassing sample. Simplified surface area apparatus and catalyst tester.

admit nitrogen from reservoir (7) to the manometer and manifold to 500 ± 1 mm Hg absolute. Remove the heater and place a dewar flask filled with liquid nitrogen (4) around the sample tube.

Note 2. The liquid nitrogen level should be held at a fairly constant level about one inch below the spherical joint. The use of a dewar cover of cardboard or similar material is recommended to reduce losses of liquid nitrogen by evaporation. A wire partially immersed in the nitrogen is also recommended for prevention of superheating.

Open valve (1) to the sample and allow the pressure on the manometer to reach equilibrium. Record the pressure and read the surface area in square meters from Fig. 4. Allow the sample to warm to room temperature while the adsorbed nitrogen is being released through valve (1). Obtain the dry gross weight. Divide the observed surface area value by the sample weight to obtain surface area in square meters per gram.

Check the purity of the liquid nitrogen with the nitrogen thermometer (Fig. 2) and this value should agree within 1 psi of the value obtained on the nitrogen used in the calibration.

Two-Point Method.

1. Procedure. Prepare and degas the sample as described in Section 3, A,(2). Fill reservoir (7) with pure nitrogen to approximately 600 mm Hg absolute, read the pressure on the manometer and close valve (6). Open valve (1) to the sample immersed in liquid nitrogen and obtain an equilibrium pressure (P_1) of 100 ± 20 mm, supplying additional nitrogen from reservoir (7) if needed (Note 3). After recording P_1, close valve (1), open valve (6) and record the pressure on reservoir (7). Then close valve (6), open valve (1) and obtain an equilibrium pressure (P_2) of 200 ± 20 using the procedure for P_1. Again measure the pressure in reservoir (7).

Degas the sample for about five minutes using the heater and vacuum and then immerse it in liquid nitrogen. Admit helium to the manometer and manifold to about 400 mm, record the pressure, and open valve (1). Record the equilibrium pressure.

Obtain the sample weight as in Section 3, A,(2). Record the nitrogen thermometer reading, the barometric pressure and the room temperature.

Note 3. If the surface area value is known to be low (less than 100), the determination can be made without

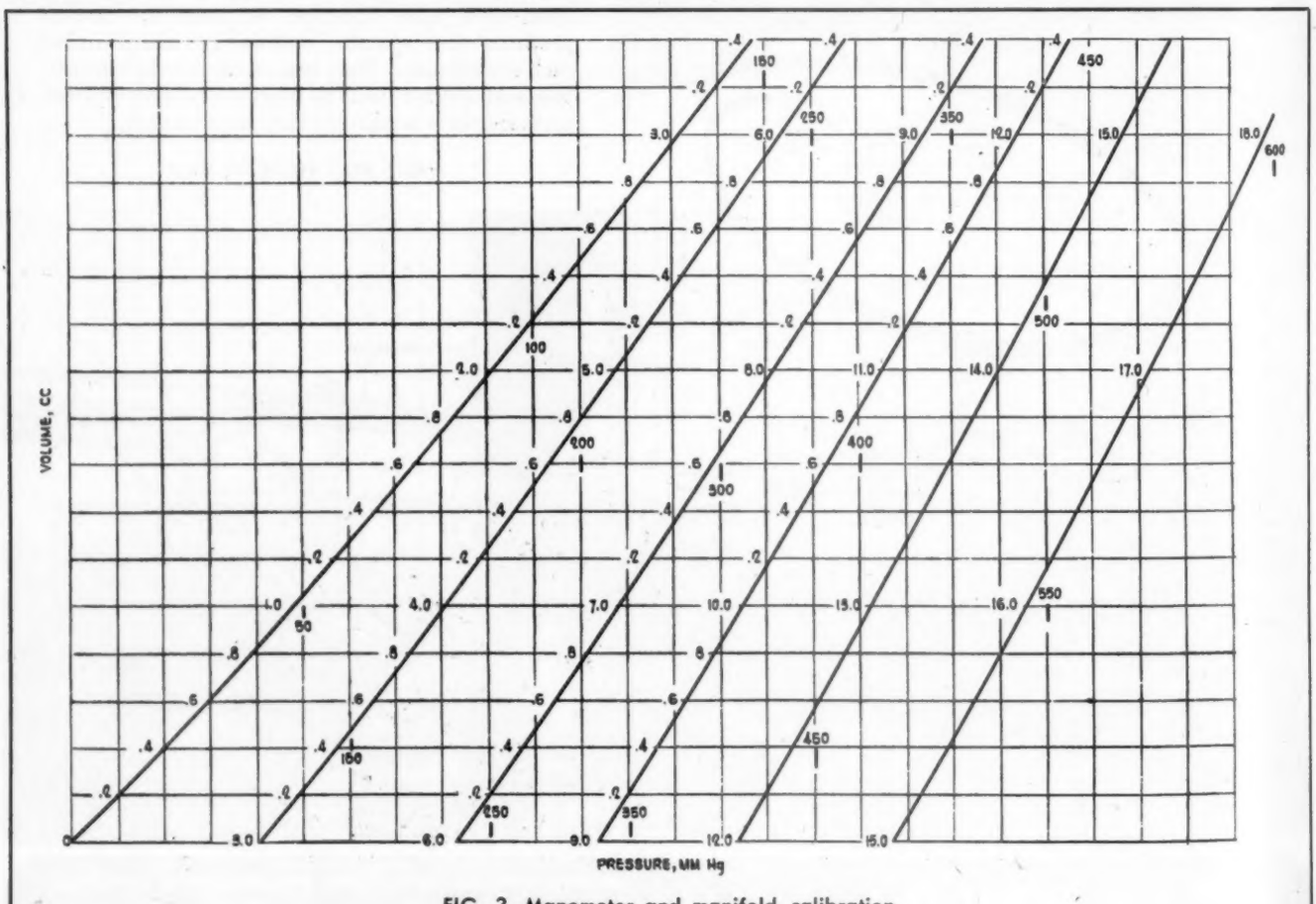

FIG. 3. Manometer and manifold calibration.

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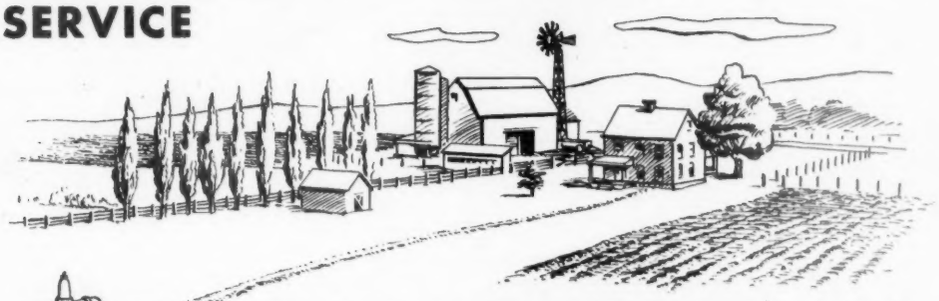

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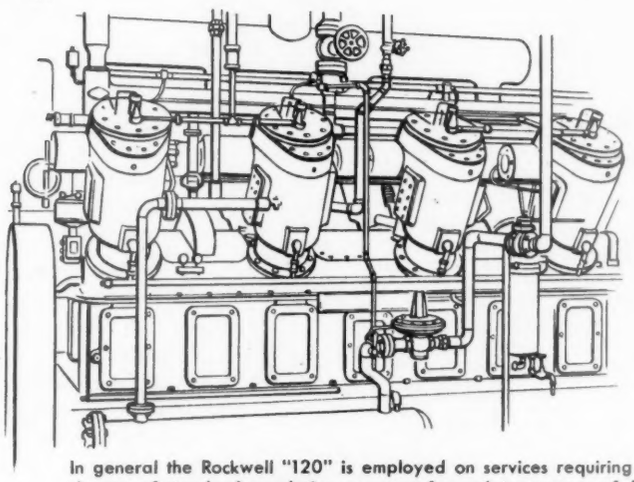
The Rockwell Farm Tap Regulator is strongly constructed with heavy duty castings, a thick, pliable diaphragm and interchangeable valves and seats. Inlet pressure range 0 to 1000 psi; outlet pressures 5 to 400 psi. Write for bulletin.

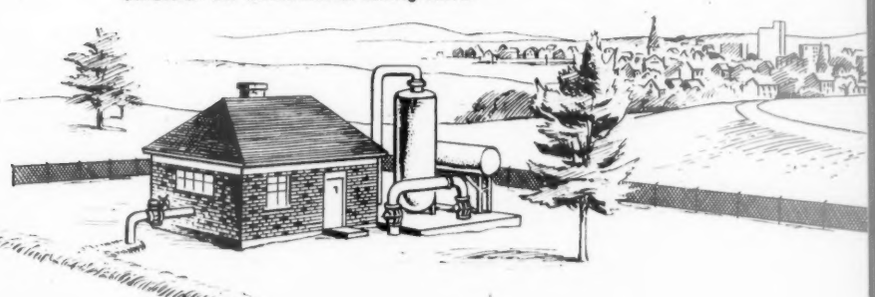
ROCKWELL "120" REGULATOR



In general the Rockwell "120" is employed on services requiring the highest degree of standard regulation accuracy for outlet pressures of 6 oz. or less where supply pressures do not exceed 5 lb.

This regulator is highly popular for gas engine service at compressor stations because it is both sensitive and strong—can be adjusted to maintain pressures of from below atmosphere to positive pressures of several ounces on the carburetor or mixing valve.

ROCKWELL HIGH PRESSURE DISPLACEMENT METER



1000 psi working pressure. Now Rockwell makes it possible to measure accurately the wide range delivery of gas from pipe line take off points with this, the first positive displacement meter ever available for working pressures above 500 psi. Made with sturdy, internally ribbed steel castings, relief valves for shock load protection, a leak resistant Teflon stuffing box and drains for removing condensate. Has a 46,000 cfh capacity of gas at 4 oz. base pressure when measured at 1000 psi. Available with standard index, Combined Record Gauge or the Emcorector.

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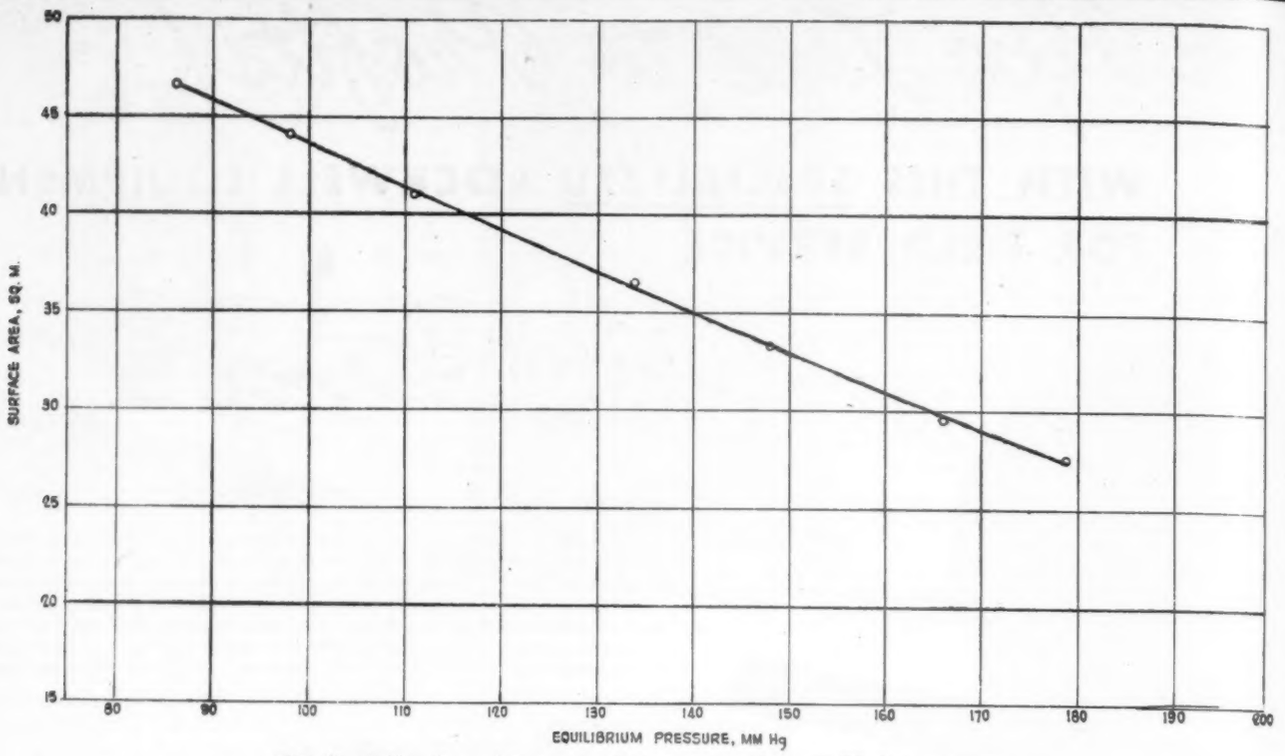

FIG. 4. Calibration of known surface area against equilibrium pressure.

additions from the reservoir (7). In this case the estimated amount required to obtain the P_1 or P_2 equilibrium pressure is admitted to the manometer. If the estimate is in error, nitrogen is added or removed as required.

Calculations—Following is a summary of the data obtained when using the two-point method.

P_1 = First equilibrium pressure, mm.
P_2 = Second equilibrium pressure, mm.
A_0 = Initial pressure on reservoir (7), mm.
A_1 = Pressure on reservoir after P_1, mm.
A_2 = Pressure on reservoir after P_2, mm.
H_0 = Initial Helium pressure in manometer, mm.
H_1 = Final Helium pressure in manometer, mm.
B_0 = Barometer reading, mm.
N = Nitrogen thermometer reading, psig.
P_0 = N × 51.7 + barometric pressure, mm.
T = Room temperature, °C.
S = Sample weight, grams.

The formula used in calculating surface area is as follows:

$$\text{Surface area} = \frac{4.383\ (P_2 - P_1)}{\left[\frac{P_0 - P_1}{P_0 - P_2} \times \frac{P_2}{V_2} - \frac{P_0 - P_2}{P_0 - P_1} \times \frac{P_1}{V_1}\right] S}$$

where V_1 and V_2 are the volumes absorbed at pressures P_1 and P_2 respectively after correcting for dead space volumes.

A sample calculation is shown below:

Experimental data

P_1 = 105 mm	H_1 = 328 mm
P_2 = 212 mm	B_0 = 753 mm
A_0 = 428 mm	N = 1.74 psig
A_1 = 350 mm	P_0 = 843 mm
A_2 = 325 mm	T = 27C
H_0 = 399 mm	S = 0.4748g

Calculation of V_1 and V_2 (Note 4)

1. 428 — 350 = 78 mm × 104.7 (Vol. of reservoir 7)/760 = 10.75 cc
2. Manometer volume at 428 mm = 11.80 cc
3. Manometer volume at 350 mm = 9.20 cc
4. 10.75 + (11.80 — 9.20) = 13.35 cc = V_1 at 27C uncorrected for dead space.
5. 350 — 325 = 25 mm × 104.7/760 = 3.44 cc
6. Manometer volume at 325 mm = 8.42 cc
7. 13.35 + 3.44 + (9.20 — 8.42) = 17.57 cc = V_2 uncorrected for dead space.
8. Manometer volume at 399 mm (H_0) = 10.83 cc
9. Manometer volume at 328 mm (H_1) = 8.51 cc
10. 10.83 — 8.51 = 2.32 cc = dead space at 328 mm pressure

By proportion the dead space at P_1 and P_2 is calculated to be:

11. P_1 dead space = 0.74 cc
12. P_2 dead space = 1.50 cc
13. 13.35 — 0.74 = 12.61 = V_1 at 27C
14. 17.57 — 1.50 = 16.07 = V_2 at 27C
15. V_1 at O C = $\frac{12.61}{300} \times 273 = 11.48$
16. V_2 at O C = $\frac{16.07}{300} \times 273 = 14.63$

Using the formula:

$$\text{Surface area} = \frac{4.383 \times (212 - 105)}{\left[\left(\frac{843 - 105}{843 - 212}\right)\frac{212}{14.63} - \left(\frac{843 - 212}{843 - 105}\right)\frac{105}{11.48}\right]0.4748} = 108.5 \text{ sq m/g}$$

TABLE 1. Experimental data.

Sample No.	Surface Area, Sq M/Gram: From Fig. 4	Surface Area, Sq M/Gram: By 2-Point Method
1	116.5	115.0
2	120.0	122.5
3	79.4	83.6
4	341.0	348.0
5	53.0	55.0

Note 4. If the manometer only is used for measuring the nitrogen as described in Note 3, Step (1) is omitted and the manometer volumes are taken as uncorrected V_1 and V_2.

Experimental Data

The data presented in Table 1 indicate that values obtained by the one-point method are in error by less than five per cent as compared to the two-point method. This accuracy is assured only when the calibration is made on samples which are similar to those being tested. ★ ★ ★

The success of Procon in handling a broad range of process construction jobs is assuring evidence of the satisfaction you may expect from any Procon project.

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Creole to Double Output At Venezuelan Refinery

A. T. Proudfit, president of the Creole Petroleum Corporation has announced that his company will double the present capacity of its largest refinery at Amuay Bay in the Venezuelan state of Falcon. He also revealed that the new installations at Amuay would permit the company to manufacture 91 octane aviation gasoline, such as is commonly used for air transport in Venezuela. The new plant will also refine some of the components of aviation gasoline of higher potency, used in the manufacture of 100 and 115 octane gasolines, in sufficient quantities for export to other countries.

When the new installations are completed at Amuay, Creole will refine nearly 200,000 bbl of crude daily at its two Venezuelan refineries located at Amuay and Caripito, Proudfit pointed out. Seventy-five per cent of this total will be destined for export.

The design work has already begun and construction on the new Amuay plant is expected to begin late in 1953. It will require from one-and-a-half to two years to complete the construction, so that the additional facilities are expected to be ready before the end of 1955.

Proudfit stressed that in addition to doubling Amuay's capacity for the refining of such products as gasoline, kerosine, diesel oil, and fuel oil, (which will bring its capacity from 60,000 bbl per day to 120,000 bbl per day), Creole is going to install an entirely new type of refining unit known as the "fluid hydroformer," which will have a capacity of 10,000 bbl per day for the refining of high octane products, including the blending stocks necessary for the manufacture of aviation gasoline.

Canadian Oil Company Opens Sarnia Refinery. Rt. Hon. C. D. Howe, Minister of Defense Production officially opened the refinery with a speech at the ceremony. Above are, Premier E. C. Manning, Alberta, speaker; W. H. Rea, president of Canadian Oil; Howe; and Premier Leslie Frost, Ontario, speaker.

Canada Refinery on Stream

The expanded and modernized multi-million dollar refinery of The British American Oil Company Limited has been put "on stream." The new plant, which incorporates Saskatchewan's first fluid catalytic cracking unit is situated in Moose Jaw.

The refinery will provide Manitoba and Saskatchewan with high octane gasolines as well as other quality petroleum products. The refinery will process approximately 15,000 bbl of crude oil daily.

Installations at the refinery include a catalytic polymerization unit and delayed coking and gas recovery units. The catalytic polymerization unit combines small molecules of gas into larger ones which are formed into high octane gasoline.

New Plant to Aid Air Pollution Control

Humble Oil and Refining Company and Consolidated Chemical Industries have announced that ground had been broken by the latter on a site adjacent to Humble's Baytown refinery for the construction of a sulfuric acid manufacturing plant.

This plant will utilize as feed stock hydrogen sulfide recovered from processing of crude and certain acid sludges resulting from various refining processes and formerly burned as fuels in the Baytown refinery.

Since the end of the war, Humble has had under active study the problem of reduction to a practical minimum of water and air pollution. Substantial expenditures in the neighborhood of $4,000,000 during that period have already produced a water effluent of satisfactory quality.

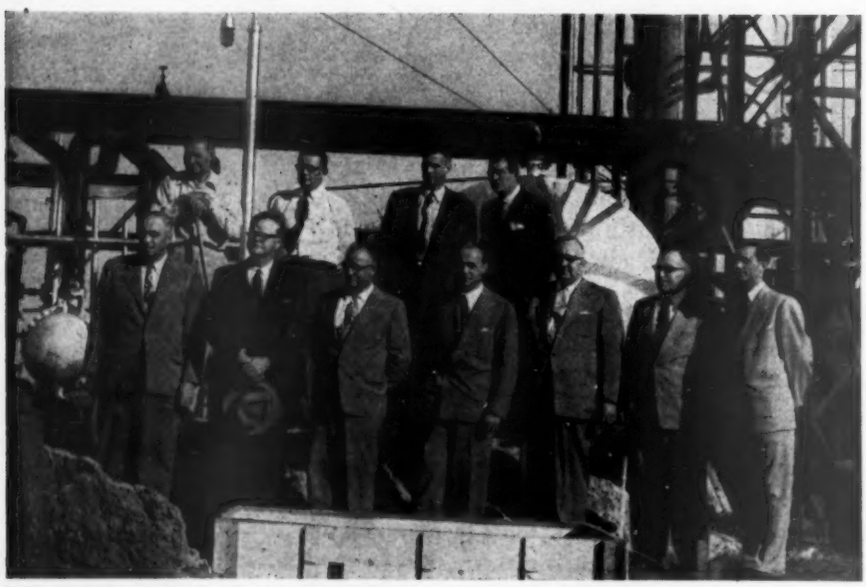
Many measures have been adopted over the past few years at Baytown refinery to reduce air pollution.

New Catalyst Plant Set

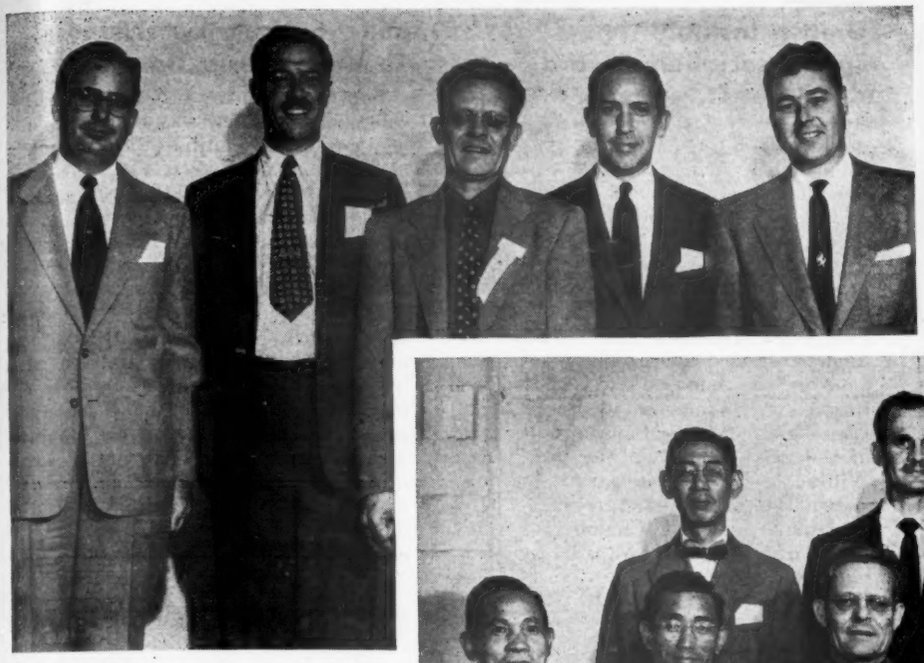
Houdry Process Corporation placed in operation at Paulsboro, New Jersey, a plant for the manufacture of Type 3 catalyst to be used in Houdriforming operations for up-grading naphthas to high octane gasolines, and the production of aromatics. The Paulsboro plant initially will produce this new catalyst for Houdriforming plants now under construction having a total capacity of approximately 25,000 bbl per day. In addition, the new plant is designed to fill future industry requirements for Houdriforming catalyst.

Sheboygan Plant Expands

Wisconsin Oil Refining Company officially began work on its new half-million dollar expansion program designed to enlarge the Sheboygan, Wisconsin, plant. Expansion will enable the company to produce gasoline of a higher octane rating, better fuel oils, and road oils. The new units will also double capacity from 5000 to 10,000 bbl per day at the refinery. (See photo at left.)



Wisconsin Oil Enlarges Refinery. Walter J. Kohler, Jr., governor of Wisconsin, and Mayor Edward C. Schmidt are shown with company officials and representatives of the Sheboygan Association of Commerce. First row: August J. Rammer, president; Foster R. Nelson, general manager; Attorney Lester C. Weisse, secretary; Governor Kohler; E. F. Klozotsky, Commerce Association president; Schmidt, and Matt Shook, Jr., executive vice president of the association. In the last row: E. W. Zwansiger, plant superintendent; Vincent Burkhart, construction engineer; Lloyd Theune, assistant general manager, Roman Brotz, director and assistant treasurer.



Speakers at Heating Seminar. Left: C. E. Rawlins, Phillips Petroleum Company; J. J. B. Rutherford, Babcock & Wilcox Tubular Products Division; Robert D. Reed, John Zink Company; E. A. Shafer, Alloy Castings Institute; R. W. Fowler, Fritz W. Glitsch and Sons.

Zink Visitors. First row: A. Jochi, Koa Oil Company, Tokyo, Japan; Y. Sugimoto, Koa Oil Company, Tokyo, Japan; Robert D. Reed (presiding at meeting), John Zink Company; D. W. Gard, Canadian Oil Refineries, Ltd., Ontario; R. Quintero, Venezuelan Government, Caracas. Back Row: Haruo Shimamura, Nippon Petroleum Refining, Tokyo; R. A. Parsons, A. G. McKee Company, Tulsa; Yi Chung Chang, University of Tulsa faculty.

Annual Heating Seminar Draws 400 Engineers

Expanding on the record of two previous one day seminars dealing with heating and fractionation problems, the Third Annual Process Heating Seminar held at the works of John Zink Company in Tulsa, Oklahoma, drew more than 400 of the Mid-Continent industry's leading engineers on October 4, 1952. This seminar has been devoted to the solution of practical problems in plant heating operations since its beginning in 1950, and its attendance at each meeting has outdistanced that of the previous meeting. The programs have been distinctive for their practicability and close attention to actual operating problems, to the advantage of all those interested in these all-important operations.

This meeting had as the main events four papers on as many subjects, all of primary interest to practically every person in attendance. These papers dealt with subjects as "Tube Failures in Process Heaters;" "Design and Maintenance of Fractionation Towers;" "Blistering of Steel in Catalytic Process Vessels," and "Heat-and Corrosion-Resistant Castings." J. J. B. Rutherford, widely known authority on steels and especially tubular goods, showed with a large number of slides and detailed running comment the causes and results of tube failures, alloys to be employed for various applications, along with methods for reducing and minimizing the number of service failures. Rutherford classified tube failures under mechanical, metallurgical, and chemical causes and discussed the details of each type, as well as preventive measures. One of the important items dealing with failures is the form of a "notch" or cut in the metal surface; a rounded bottom cut is less prone to cause easy failure than is a scratch with a sharp V-notch bottom, he said.

One of the outstanding and most troublesome problems arising from catalytic cracking operations is the hydrogen "blistering" of the steel in reactors, which is causing considerable trouble in refinery units. C. E. Rawlins of Phillips Petroleum Company made a "progress report" on investigative work in this field but, because the conclusions drawn are tentative they are not to be announced until further work is done to determine both causes and successful preventive measures for this critical problem.

Development of the truss type of bubble plate, of stainless or other alloy steel to replace the cast-iron type of tray and bubble cap was the result of a long period of study to eliminate the inherent buckling, cracking, breakage, and great weight of cast trays, according to R. W. Fowler, sales chief for Fritz W. Glitsch and Sons. Innumerable difficulties arose, means of fastening plates to tower wall, expansion joint design, tray support, which resulted finally in developing the truss support method now in use for such trays.

The more highly specialized types of operations in refining of today require more specialized equipment to carry out those processes and to withstand the generally very gruelling treatment the equipment receives. The development, properties, and applications of alloy castings to refinery equipment design was presented by E. A. Shoefer of the Alloy Castings Institute who discussed the use of various types as applied to different purposes. Two of the important items on the agenda of the meeting were the request for suggestions as to subjects to be discussed at the Fourth Annual Seminar in 1953 at about the same date, a request made to all registrants from which suggestions the subjects for next year's meeting will be chosen.

PAD Officials Survey Refineries in Europe

Two officials of the Petroleum Administration for Defense have left for Europe to survey refinery facilities in France, Italy, the Netherlands, Belgium, Germany, and the United Kingdom, Deputy Petroleum Administrator J. Ed Warren announced.

The two officials are J. E. Brantly, assistant deputy PAD Administrator in charge of foreign petroleum operations, and W. Vaughn Ischie, director of PAD's foreign refining division.

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Grease Institute Wins Top Association Award

The National Lubrication Grease Institute has been presented with the grand award for outstanding service to its members and the general public. Presentation was made at Toronto, Canada, to the organization's executive secretary, Harry F. Bennetts.

The award is known as the grand award for distinguished service and is presented to the trade association judged by a jury of awards to have rendered the greatest service among all associations entering the contest. The awards jury this year was comprised of: Secretary of Commerce, Charles Sawyer, chairman of the jury. Others on the jury were: William J. Grede, president, National Association of Manufacturers; Dechard A. Hulcy, president, Chamber of Commerce of the U. S.; Edward H. Stromberg, Northwestern University; Dr. Ray B. Westerfield, Yale University.

Basis for the award was a program of cooperation with other industries resulting in standardization of all containers used by the petroleum industry.

New Retort Completed At Rifle, Colorado

The Bureau of Mines has reported that construction has been completed in Rifle, Colorado, on a demonstration-scale retort that will employ a relatively new and very promising process for continuous extraction of oil from oil shale.

This unit, built by the Blaw-Knox Construction Company of Pittsburgh, Pennsylvania, is patterned after a 6-ton-a-day pilot plant that has proved the "gas combustion" process both the most efficient and most economical ever developed at Rifle, according to J. H. East, Jr., Bureau regional director.

A series of "dry run" tests will be made before the new retort is fired and placed in operation about January 1, said Boyd Guthrie, Chief of the Bureau's Oil-Shale Demonstration Branch. By that time, he added, a raw shale storage and distribution system being built for this retort by Blaw-Knox under another contract also will be completed.

Fluidized Bed Process For Ethylene Oxide

Vulcan Engineering Division, Cincinnati, Ohio, announces a new fluidized bed process for the production on a commercial scale of ethylene oxide by direct oxidation of ethylene gas with air. Vulcan and Atlantic Refining Company joined in the project.

The fluidized bed consists of the agitated suspension of a fine catalyst solid in a rapidly moving gas stream. This contrasts with fixed bed processes which employ a catalyst in the form of large particles which are not being agitated and mixed by the gases. In the fluidized bed the agitation serves to keep a uniform temperature throughout the catalyst bed and prevents the formation of "hot spots." Thus the Atlantic-Vulcan process allows much better temperature control in the all-important reactor resulting in uniformly high yields of oxide.

Sun Develops Catalyst To Burn Waste Gas

Sun Oil Company has announced development of a new waste-burning catalyst designed to utilize waste gases to make steam and electricity. The company stated its belief that the catalyst would ultimately save American industry millions of dollars yearly in salvaged wastes, and will eliminate air pollution at the same time.

Developed by Eugene J. Houdry, inventor of the process of catalytic cracking petroleum, the new oxidation catalyst is basically of catalytic alumina and platinum alloy. Waste carbon monoxide and hydrocarbons blown out of petroleum-cracking reactors at Sun in a continuous stream, are burned as they pass through the catalyst. Eighty per cent of the heat is converted to steam, the remainder through a gas turbine, to electric power.

Refining Plants Offered

Hydrocarbon Research, Inc., of New York has announced the establishment of a cooperative undertaking with Edeleanu Gesellschaft, M. B. H. of Frankfurt, Germany, whereby solvent refining plants incorporating the latest process developments of Edeleanu and Hydrocarbon will be offered to petroleum refiners. Emphasis will be placed on the design of plants for the production of paraffinic feed stocks for catalytic cracking, and of high quality burning oils and fuels.

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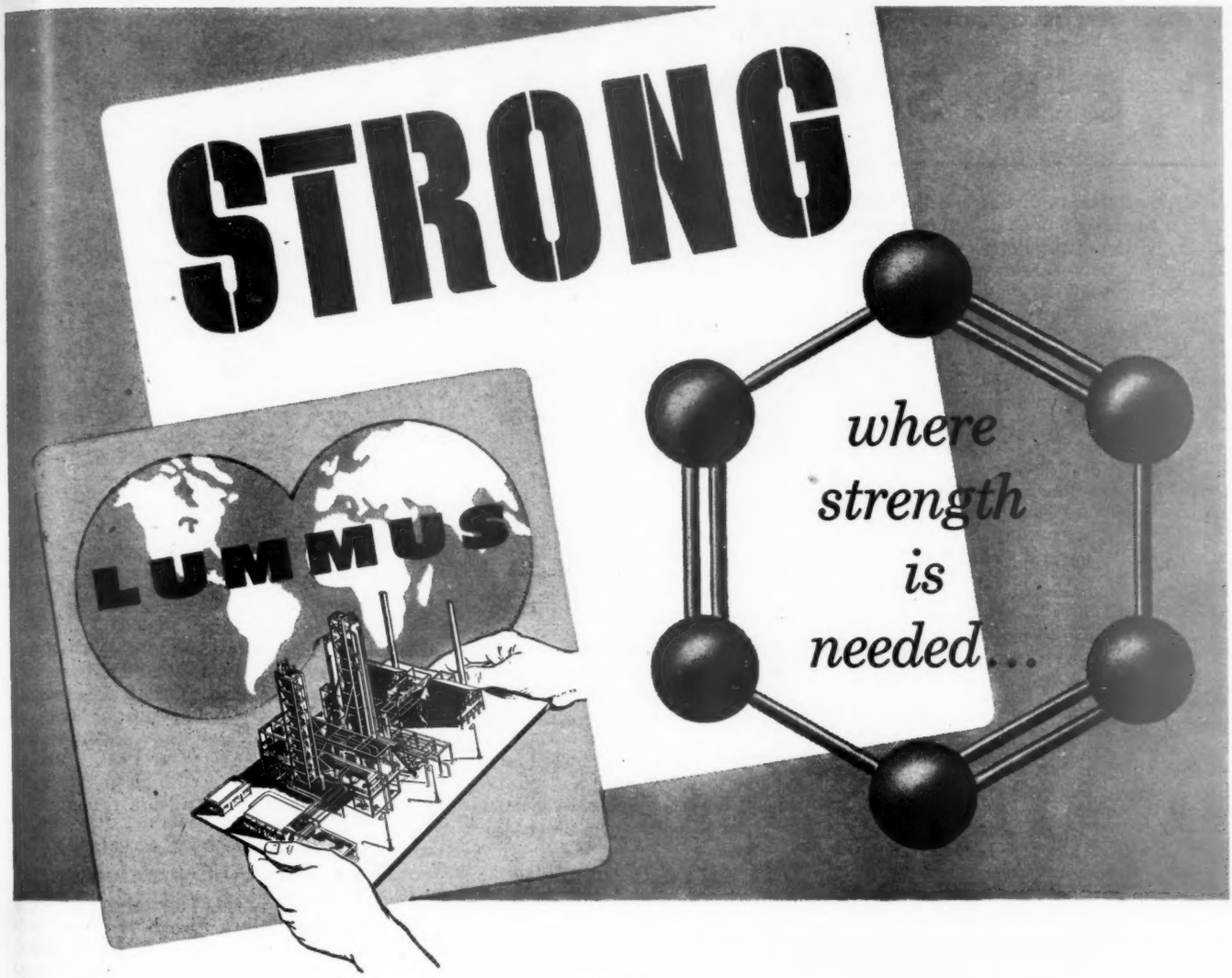

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PERSONALS

▸ **Harris Bateman** of Bartlesville, Oklahoma, has been named director of materials division of the Petroleum Administration for Defense, succeeding **Richard M. Morrison** of New York City, who has returned to private industry. Bateman joined PAD in mid-August as deputy director of Materials Division.

He was chief engineer for Cities Service Oil Company at the time he joined PAD. He has worked for the company since 1927, when he graduated from Oklahoma A and M College.

Morrison, manager of the purchasing department for The Texas Company from 1947 until joining PAD. He had been with the company since 1917.

▸ **Thomas C. Keeling, Jr.,** Pittsburgh, Pennsylvania, has been named deputy director of the chemical division of the National Production Authority, Department of Commerce. Keeling is on leave from his position as assistant vice president of the chemical division of the Koppers Company, Inc., where he has been employed since 1945. He is a graduate of the Massachusetts Institute of Technology.

▸ **Dr. R. W. Millar** has been appointed head of the chemical engineering department at Shell Development Company, leaving **Dr. Mott Souders, Jr.,** free to devote his attention to his principal duties as associate director of development. **Dr. C. L. Dunn** succeeds Millar as head of the physical chemistry department, and **Dr. R. L. Maycock,** formerly development supervisor, replaces Dunn as assistant department head.

▸ **Wayne H. Keller** has been named director of the chemistry department, National Research Corporation.

Keller, a native of Kentucky, brings with him a wide background of experience which will be particularly useful in his work for National Research. He did his undergraduate work at Georgetown College, Georgetown, Kentucky, and graduate work at the University of Kentucky and Cornell University. He received his Ph.D. in physical chemistry from Cornell in 1937.

Keller joined the uranium project at Iowa State College, Ames, Iowa, in 1942, where he was director of chemical metallurgy for the Manhattan district program. He was one of the co-developers of the process by which uranium is made and also contributed to the development of making other metals necessary to atomic energy projects.

▸ **P. C. Livesay,** assistant general superintendent of Standard Oil Company's Whiting, Indiana, refinery, will become manager of the projects, capital expenditures, and miscellaneous contracts division in the company's general office manufacturing department at Chicago. Livesay joined Standard in 1937 as an engineer at Whiting. In 1943 he became foreman and in 1946 general foreman of the heavy oils division. He was appointed superintendent of the projects division in 1948 and assistant general superintendent of the refinery in 1950.

▸ **Edwin F. Nelson** has been elected president and general manager of Lake Superior Refining Company, Superior, Wisconsin. Officers re-elected at a meeting of the board were **H. J. Underhill,** vice president, **R. A. Crawford,** secretary, and **Leslie Olsen,** treasurer.

Nelson has, for many years, taken an active part in the problems of petroleum refining, particularly relating to the development and application of refining processes for the production of improved quality products.

▸ **George W. Jandacek** has joined the staff of the research and development department of Deep Rock Oil Corporation. Jandacek will serve as a chemical engineer and will be stationed at Cushing, Oklahoma. A graduate of Northwestern University, he was employed by a petroleum engineering company in Chicago before joining Deep Rock.

▸ **W. H. Sloan** is back with Cities Service Oil Company's gasoline-chemical division after a tour of duty as lieutenant colonel in the Army's Frankford arsenal in Philadelphia. Sloan has moved his family to Bartlesville, Oklahoma, and will resume his old job as head of the gasoline-chemical division's new projects department.

▸ **Richard T. Lyons** of Houston, Texas, has been elected president, chief executive officer and a director of Union Sulphur and Oil Corporation. Herman F. Whiton, chairman of the board, relinquished the presidency, but will continue active in the affairs of the company.

Lyons has been vice president in charge of exploration in the Mid-Continent division of Tide Water Associated Oil Company for the past 16 years. Previously he was vice president and director of Skelly Oil Company. He will make his headquarters in the company's office in Houston, which will become the chief executive office.

▸ **G. L. Glespen,** who held the post of chief of chemicals, containers and packaging branch of the Petroleum Administration for Defense, Materials Division during a ten months' leave of absence from American Cyanamid Company, has returned to the firm's New York office as assistant to the manager of the petroleum chemicals department. Before leaving for his PAD assignment, Glespen was technical supervisor in the same department.

▸ **Clyde V. Quinn** has been promoted to area superintendent for Texas Natural Gasoline Corporation. In his new capacity, Quinn will supervise all field operations. Quinn attended the engineering college of Washington University at St. Louis, Missouri. In 1924, he was employed as roustabout for the Magnolia Petroleum Company at Oilton, Oklahoma, and was rapidly advanced during the next several years to position as district superintendent for that company.

In 1948 Quinn was employed by Texas Natural Gasoline Corporation as construction and operating superintendent of its first plant in the Wimberly-Reddin field near Abilene, Texas. He later supervised the building of Texas Natural's Walnut Bend plant near Gainesville, Texas, and has more recently supervised the expansion of the company's Benedum gasoline plant near Rankin, Texas.

B-A Expands Refinery At Clarkson, Ontario

Ole Berg, Jr., president of The British American Oil Company Limited, announced plans for an $8,000,000 addition to the company's refinery at Clarkson, Ontario, 20 miles west of Toronto.

Berg said that a catalytic cracking unit, a catalytic polymerization unit, gas concentration, and other facilities will be installed. Opened in 1943, Clarkson refinery has produced high quality gasolines and other petroleum products.

Standard Texas Completes $10,000,000 Expansion Plan

M. P. Paret, Jr., vice president of the Standard Oil Company of Texas, announced the completion of a $10,000,000 refinery expansion program at the company's plant at El Paso, Texas.

The new facilities include a synthetic crude unit and a Houdriflow catalytic cracking unit, each rated at 11,500 bbl per day and designed for equal quantities of fresh feed and recycle charge. Other major units include a 7555 bbl-per-day vacuum flash unit, a gas recovery plant and an alkylation plant capable of producing 1400 bbl of 100/130 octane aviation gasoline daily.

Paret said the new equipment installed by Catalytic Construction Company would increase daily crude capacity from 18,000 bbl to approximately 25,000 bbl with cracking capacity increased to more than 17,000 bbl. The quality of motor fuels the refinery is capable of producing would also be greatly improved, Paret said.

Building Begins on New Australian Refinery

Work has already begun on Anglo-Iranian Oil Company's new refinery in western Australia. The new plant expansion will cost about $112,000,000 and is expected to be ready to begin operation late in 1955.

The Australian refinery will process about 60,000 bbl a day of crude oil from the Middle East, and is expected to provide 40 per cent of the country's oil requirements—estimated to be 150,000 bbl a day by 1955.

Demonstration of the Shell portable engine indicator at Thornton Research Center's stand in The Physical Society's 1952 Exhibition of Scientific Instruments and Apparatus, London. This indicator has been designed for diagnosis of engine troubles in the field, and particular attention has been paid to insure that its application requires an absolute minimum of preparation.

Shell Apparatus Exhibited in London

At the British Physical Society's 36th Exhibition of Scientific Instruments and Apparatus held in London recently, equipment designed and built at Shell's Thornton Research Center was demonstrated.

Two items were displayed at the Thornton stand, one stressing the Center's work on the application of petroleum products, and the other revealing its interest in the chemical background.

The Thermistor Ebullioscope, designed and made at Thornton, is employed for the rapid and precise determination of molecular weights on a routine basis. Such measurements are the chemists' yardstick of molecular size and are of importance in many branches of oil technology.

This apparatus employs the phenomenon of the elevation of the boiling point, and for various technical reasons it is essential that small temperature differences be measured accurately.

In the present appliance this is achieved by the proper use of temperature-sensitive electrical resistance elements known as "Thermistors," and by appropriate design of the ebullioscope itself, with the result that boiling point elevations may be measured to about 0.00025 C, i.e., with a precision several times better than is possible with the most sensitive mercury-in-glass thermometers. Moreover, measurements can be made as fast as increments of the substance under test can be weighed out in contrast to the previous techniques whereby about 20 min was required for the thermometers to attain a steady reading. A feature of this equipment is the way in which the electrical and chemical parts of the apparatus have been integrated in the engineering design.... V.S.S.

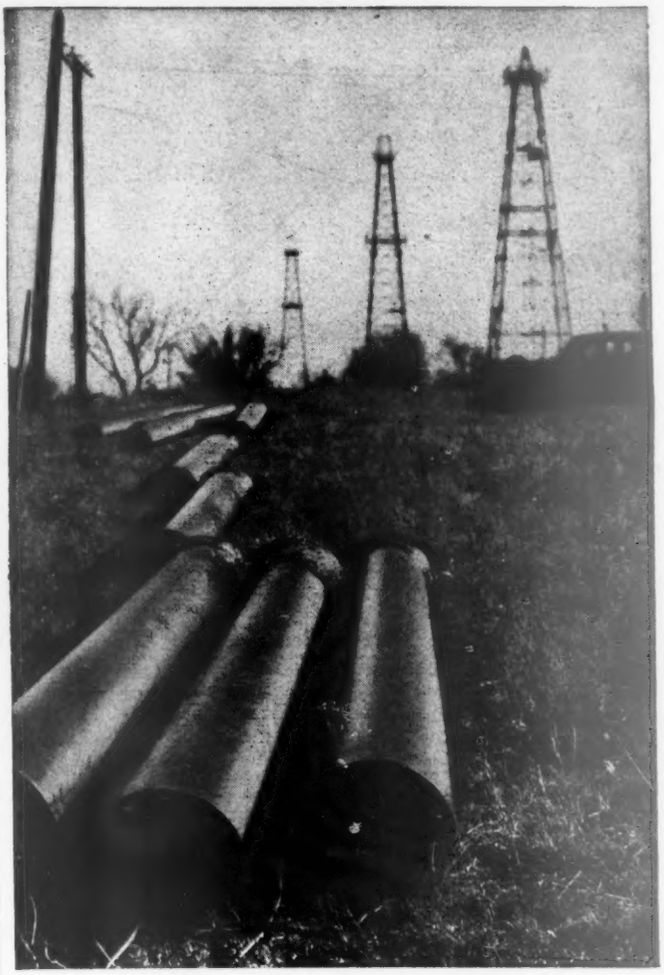
Phenol Plant Announced by Standard

Standard Oil Company of California has announced plans for construction of a phenol plant at Richmond, California.

This will be the first phenol plant in the West and will cost approximately $4,000,000. Actual construction is scheduled to start early next year and the plant is expected to be completed about the end of the year.

Installation will utilize a recently-developed synthesis process in which neither sulfuric acid nor chlorine is used. Principal uses of phenol are in the manufacture of resins for moulded plastic parts, and in plywood adhesives. Other uses are as an intermediate in the manufacture of dyestuffs and insecticides.

Stone and Webster Corporation was awarded the contract.



AN OLDTIME RECIPE FOR LONG-LIVED PIPE LINES

A recipe that waterworks and gas distribution engineers have used for over a century is: *specify cast iron pipe.* Refinery engineers have used it, too—with good success—for run-down, water and gasoline lines—for fire protection systems—salt water disposal—condenser and cooling coils.

No other pipe, at reasonable first cost, offers comparable resistance to both interior and exterior corrosion. No other pipe, in its price range, is as economical in the end. Available with bell-and-spigot, plain end and flanged, or with standardized mechanical joints. Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 1015 Peoples Gas Bldg., Chicago 3, Illinois

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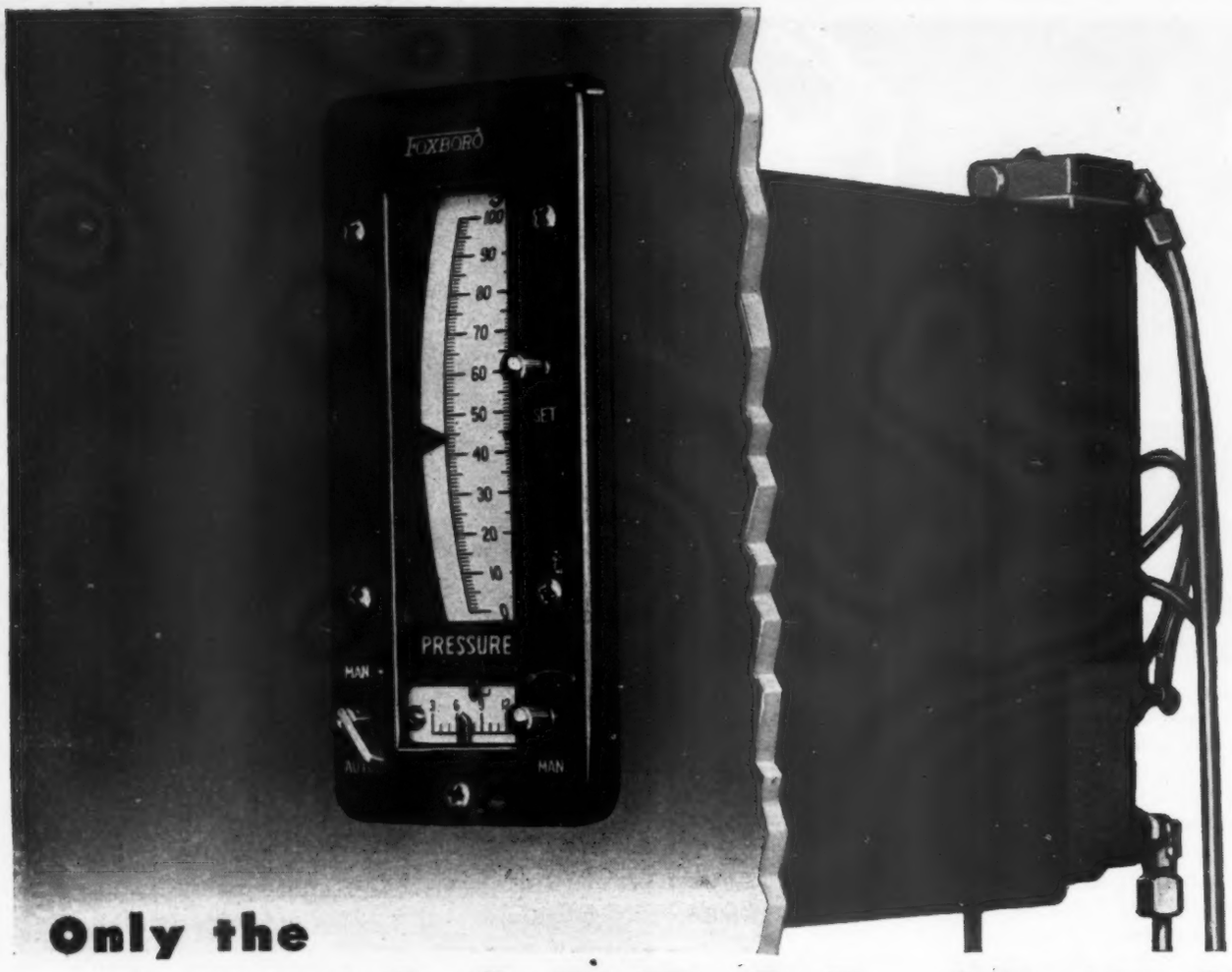

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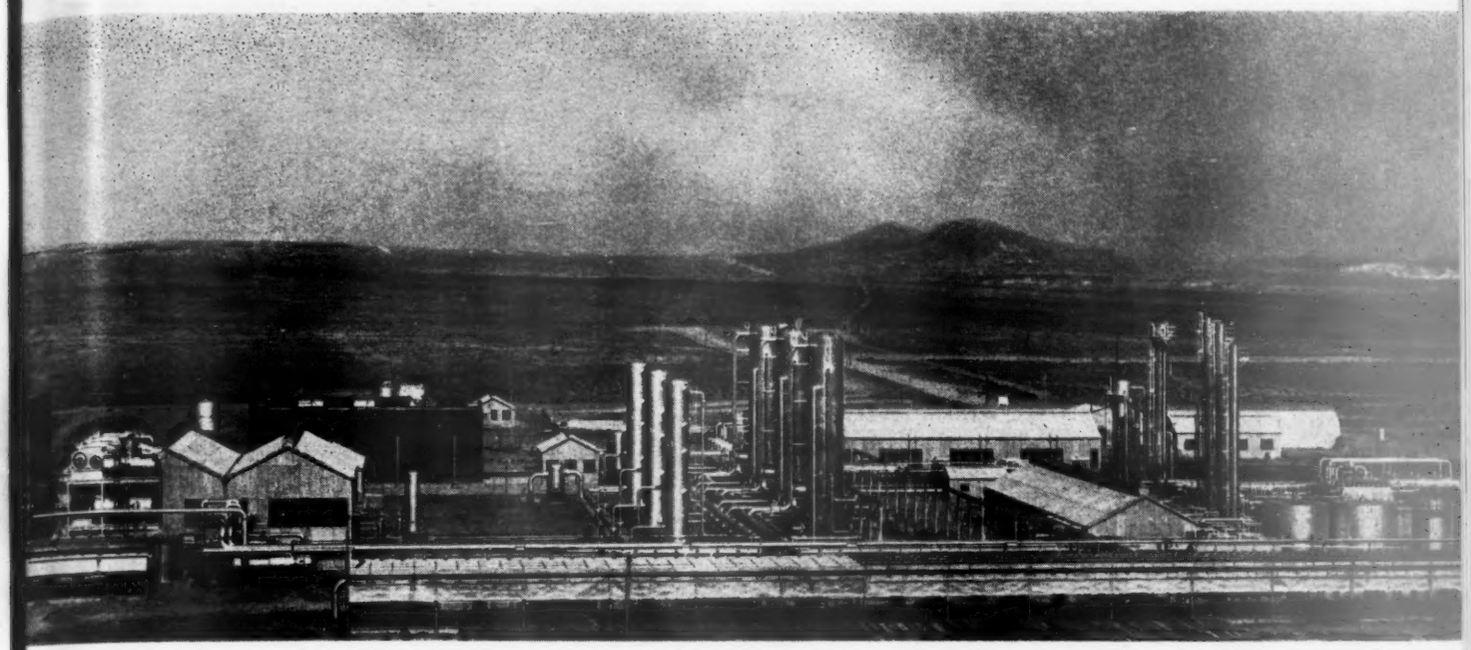


Over-all view of the San Juan River Plant of El Paso Natural Gas Company. This plant is situated two miles northeast of Fruitland, New Mexico.

San Juan River Treating Plant World's Largest

Purification unit receives 143,000,000 cu ft of gas a day and delivers 117,000,000 cu ft of pipe line gas to El Paso Natural's System

B. MARSHALL WILLIS

THE San Juan pipe line of El Paso Natural Gas Company stretches 450 miles from San Juan County, New Mexico, across northern Arizona to the Arizona-California border. At the western end, the line ties-in with a 30 in. line that comes north from the southern (Permian Basin) line of El Paso Natural Gas Company. Through the line, 167,000,000 cu ft of gas are delivered each day, 150,000,000 to Pacific Gas and Electric Company for distribution in northern California and 17,000,000 to communities in northwestern New Mexico and northern Arizona.

This gas is drawn from four fields in the San Juan Basin: Barker Creek Dome, Blanco, Largo, and Angel Peak. The gas in these fields varies widely in terms of pressure and content. Barker Creek Dome gas, for example, is very high in pressure, contains a high volume of acid and waste gases, but has no significant liquid hydro-carbon content. Gas from the other fields, on the other hand, is much lower in pressure, relatively pure in terms of acid and CO^2 content, but relatively rich in gasoline, propane, and butane.

The Author

B. Marshall Willis is advertising and publicity manager of the El Paso Natural Gas Company.

He has been employed by El Paso Natural for six years. In addition to his present job, he has served as accountant, measurement engineer, and as editor of *The Pipeliner*, the company magazine.

Before beginning work with El Paso Natural Gas Company he was, for one year, senior industrial engineer of a firm manufacturing valves and industrial instruments, and for three years market and sales analyst for United States Rubber Company.

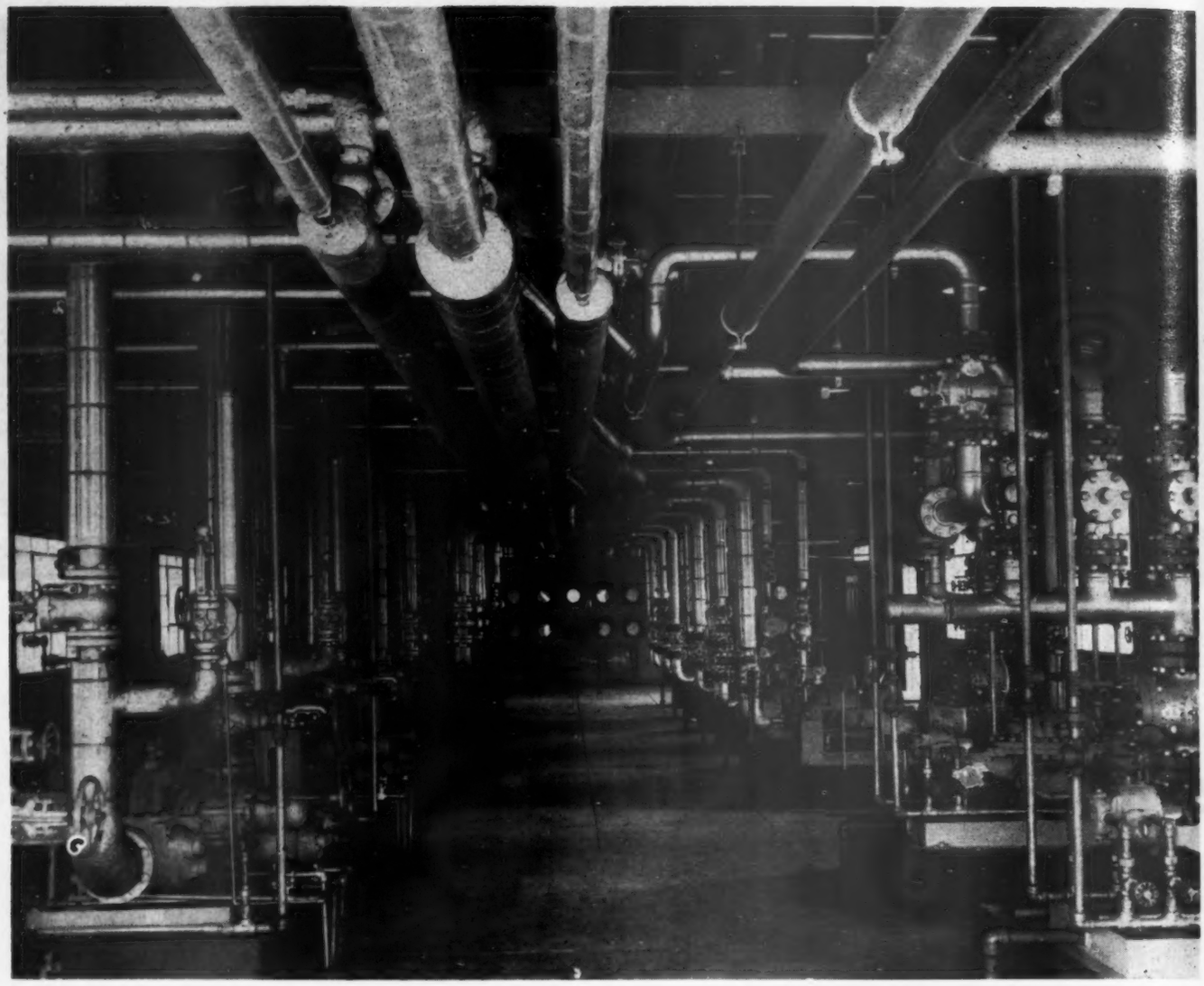
He is a graduate of Texas Western College and of Harvard University's Graduate School of Business Administration.

EXCLUSIVE

To handle the production from the various fields—to bring the gas to the mainline uniform in pressure and content—facilities covering 18 acres were erected north of Fruitland, New Mexico. Known as the San Juan River Plant, this installation is of interest in several respects. The purification unit, for example, is the world's largest in terms of volumes of gas treated.

This purification unit was designed to process natural gas from the Barker Creek Dome. Shut-in pressure of Barker Dome wells is about 2800 psi. Production is from the Pennsylvania formation at depths of about 9700 ft. Because of the high pressure, Barker Dome gas is not compressed. Rather, pressures are reduced at the well to about 825 psi.

The gas from Barker Dome well is carried through a 40-mile pipe line to the purification unit of the San Juan River Plant. Here the gas is purified by the glycol-amine process. In this process, diethylene glycol (to recover water) and monoethanolamine, to recover hydrogen sulphide and carbon-dioxide) are mixed into one treating



Gasoline plant pump room.

solution for simultaneous purification and dehydration.

The treating solution and the natural gas are brought together in contractors, the gas being introduced into the bottom of these vessels and moving upward and the treating solution being introduced into the top of the vessels and moving downward. The impure treating solution is removed from the bottom of the contractors and carried to stills where the waste and acid gases are "boiled out".

The purification unit of the San Juan River Plant receives 143,000,000 cu ft of gas a day and delivers into the mainlines 117,000,000 cu ft of pipe line gas. The balance, 26,000,000 cu ft of gas a day, represents the volumes of acid and waste gases. About 1,430,000 cu ft of this is hydrogen sulfide; the rest is carbon dioxide. To remove the high quantity of acid and waste gases from the natural gas, the purification plant pumps 3300 gal of treating solution per minute. The gas is passed through the contactors at a pressure of about 825 psi in contrast to the company's plants in the Permian Basin where the purification plants operate at a pressure of about 550 psi.

The purification unit at the San Juan River Plant has three contactors and three stills. This, again, is a change in design from most of the plants constructed previously in the Permian Basin where one still is geared to several contactors. With three stills in operation, the shut-down of one for repairs does not shut-down the entire plant as would be the case if one still served all contactors. Thus, although the use of three stills represents a slightly greater original investment, in the long run it achieves greater efficiency and economy.

After being passed through the purification unit, gas from Barker Dome is intermingled with natural gas from the other fields (which have been put through the gasoline plant described in later paragraphs) and put through a dehydrator that uses a solid substance, bauxite, to absorb liquids. The unit consists of two large horizontal cylinders filled with bauxite. Natural gas is introduced into one end of a cylinder and withdrawn from the other end, passing through the bauxite in its journey through the cylinder. The bauxite absorbs the liquids.

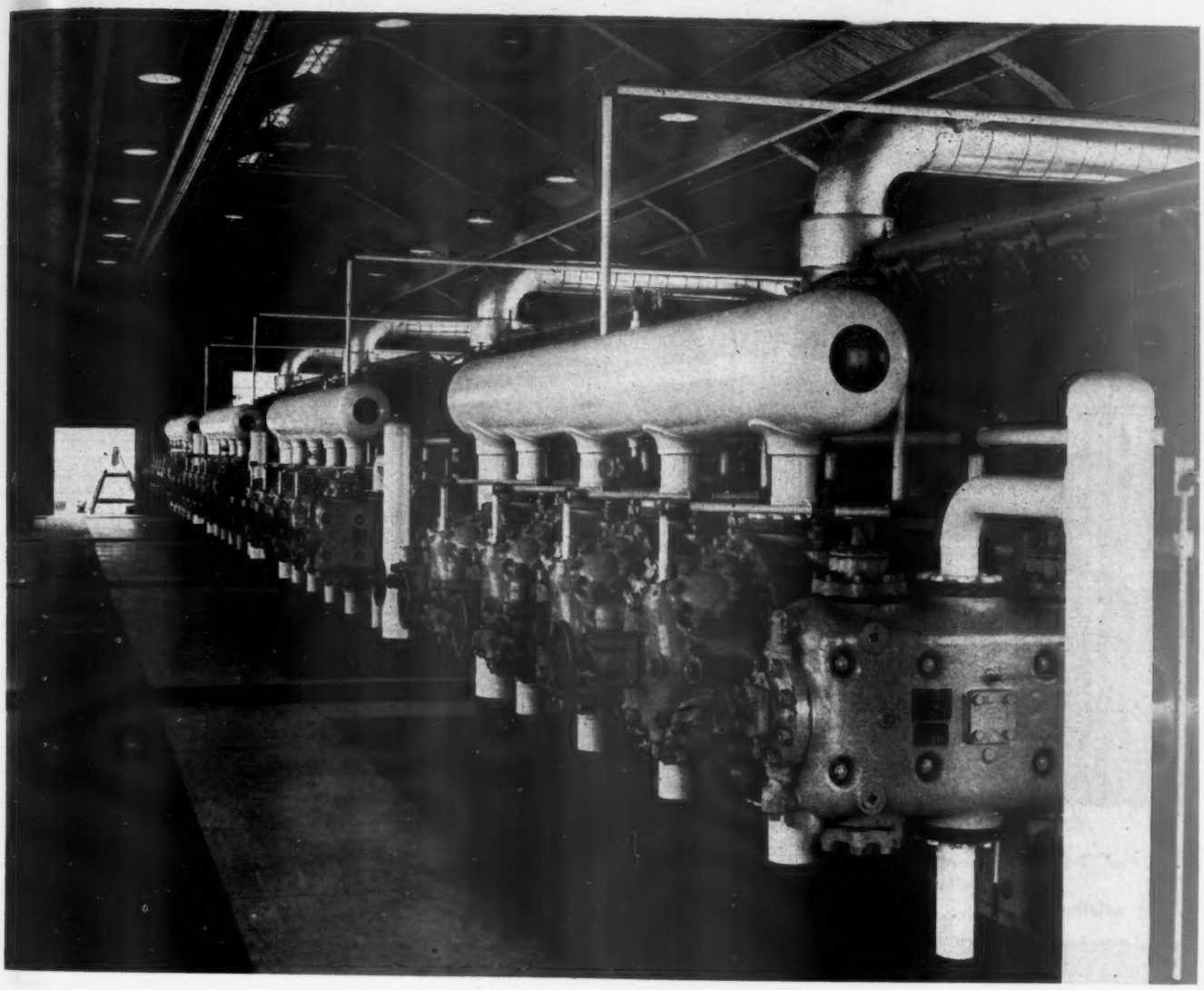
As the bauxite becomes saturated, the flow of gas is directed through the second cylinder. To reactivate, dry natural gas from the active cylinder is heated and reversed through the saturated cylinder. The high temperature of the gas causes the liquids to be absorbed by it. The hot, wet natural gas from the saturated cylinder is put into a cooler where the liquids condense.

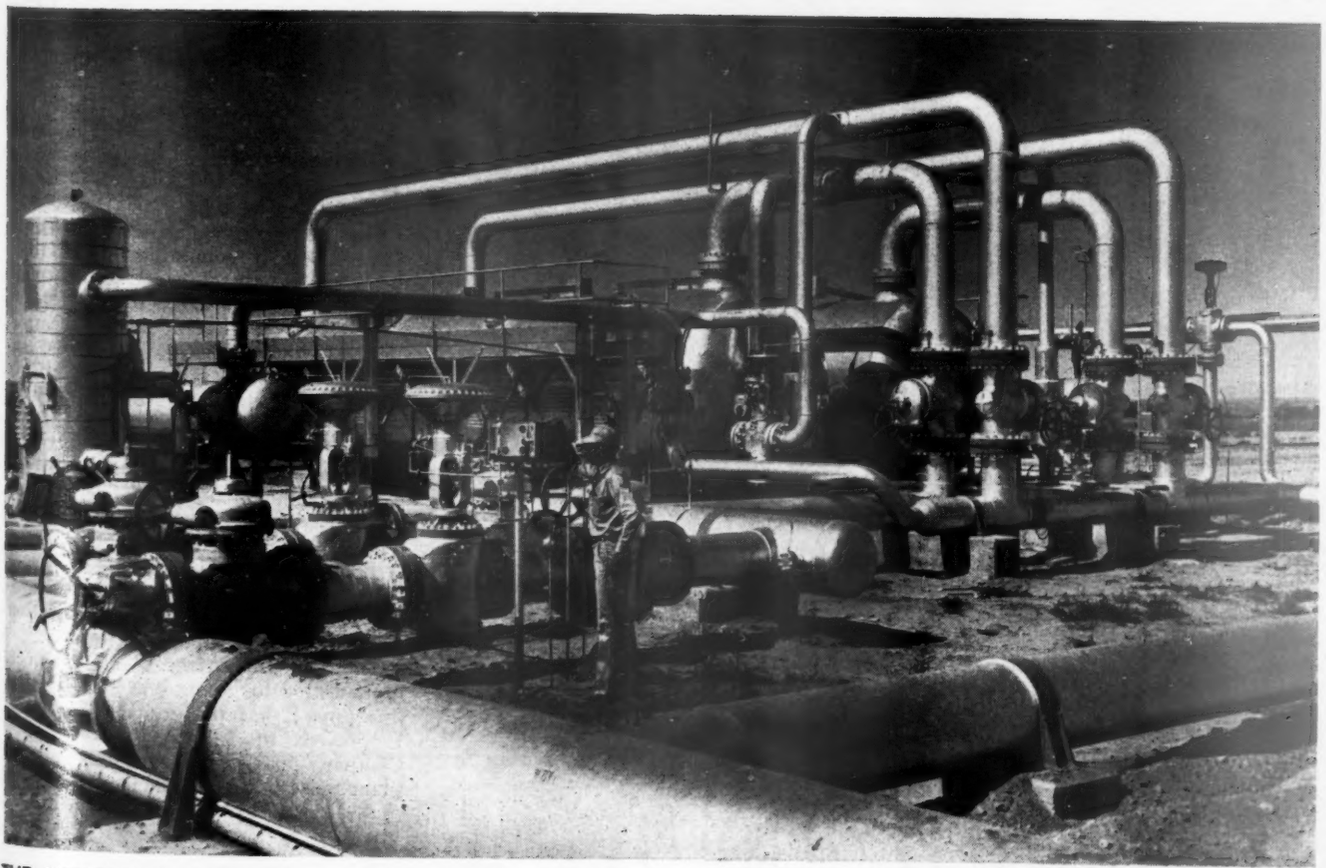
This solid dehydrator effectively removes all liquids from the natural gas, including any traces of treating solution, mineral seal oil, or lubricating oil from the compressor units through which the Blanco, Largo, and Angel Peak gases pass.

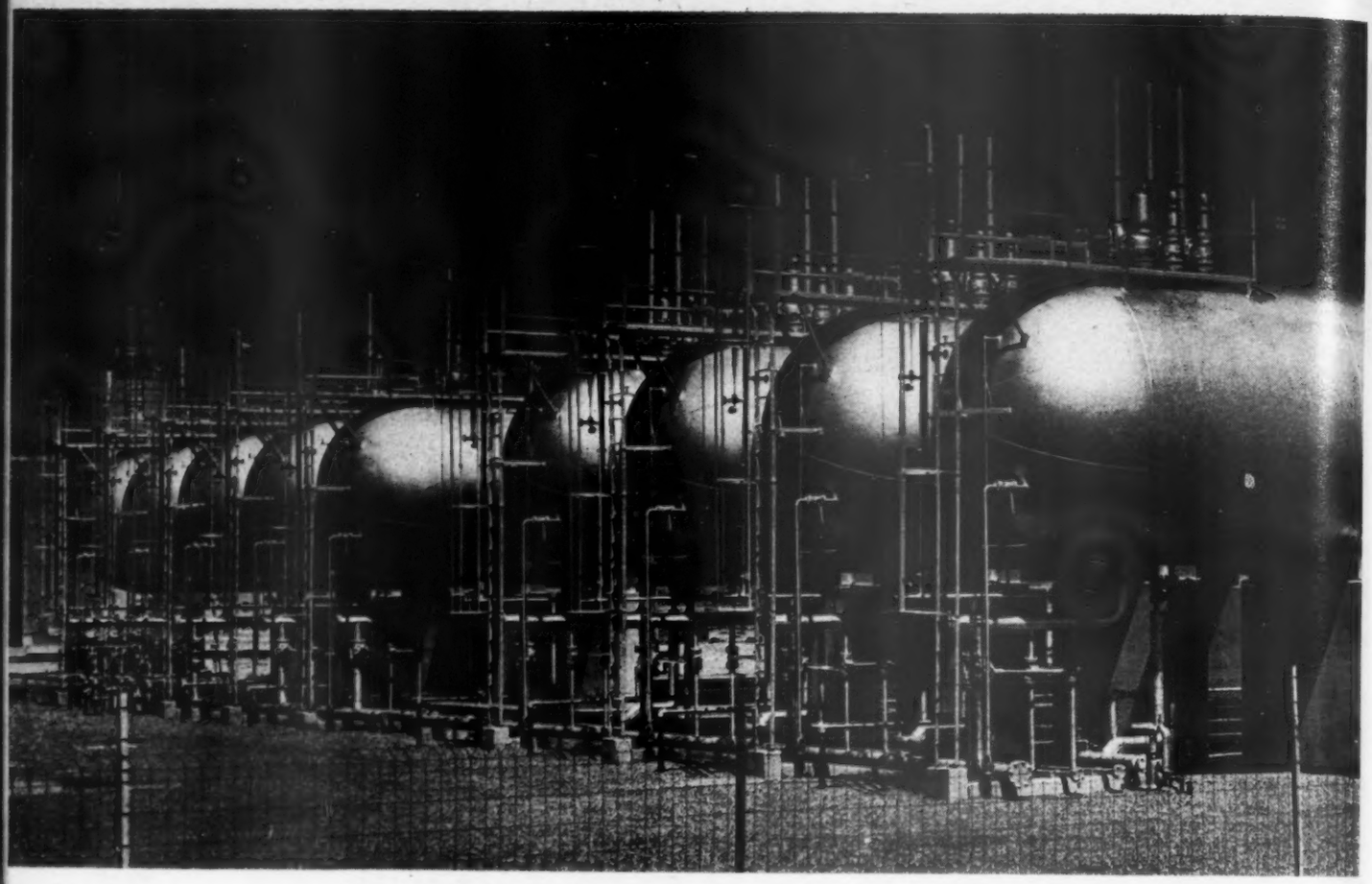
Natural gas from the Blanco, Largo, and Angel Peak fields is put through the gasoline unit at San Juan River Plant. The capacity of this plant is 70,000,000 cu ft a day. Daily production of liquid hydrocarbons is about 20,000 gal of 12-lb gasoline, 17,000 gal of butane, and 17,000 gal of propane.

Above, right, interior of the compressor plant at the San Juan River plant. This unit compresses gas from the Blanco, Largo, and Angel Peak fields prior to processing the gas in the gasoline plant.

Right, is the solid dehydrator unit Using a solid dehydrator, bauxite, this unit removes all liquids from gas including traces of treating solution, compressor oil, and mineral seal oil.

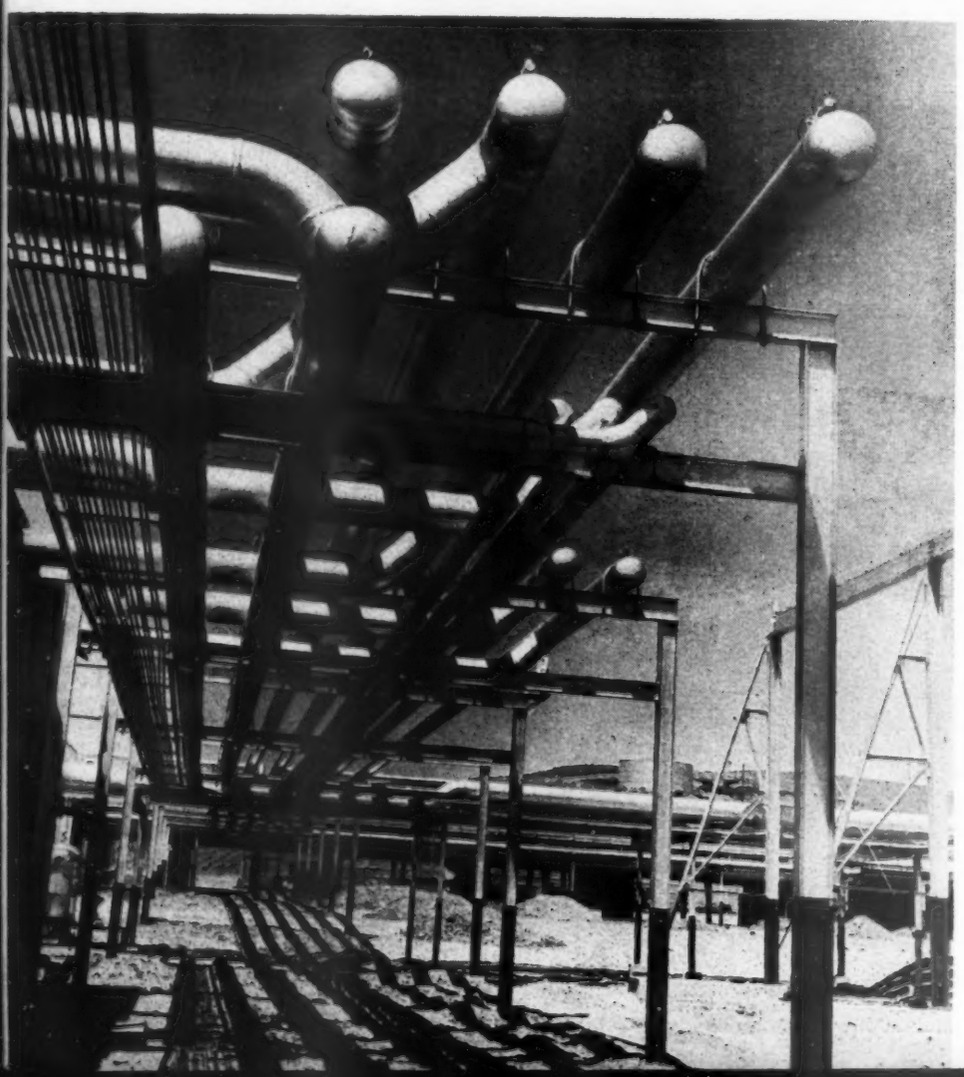






Storage tanks for gasoline, propane and butane. El Paso Natural Gas Company is planning to construct a products pipe line to carry output of the San Juan River plant to a railroad near Gallup, New Mexico.

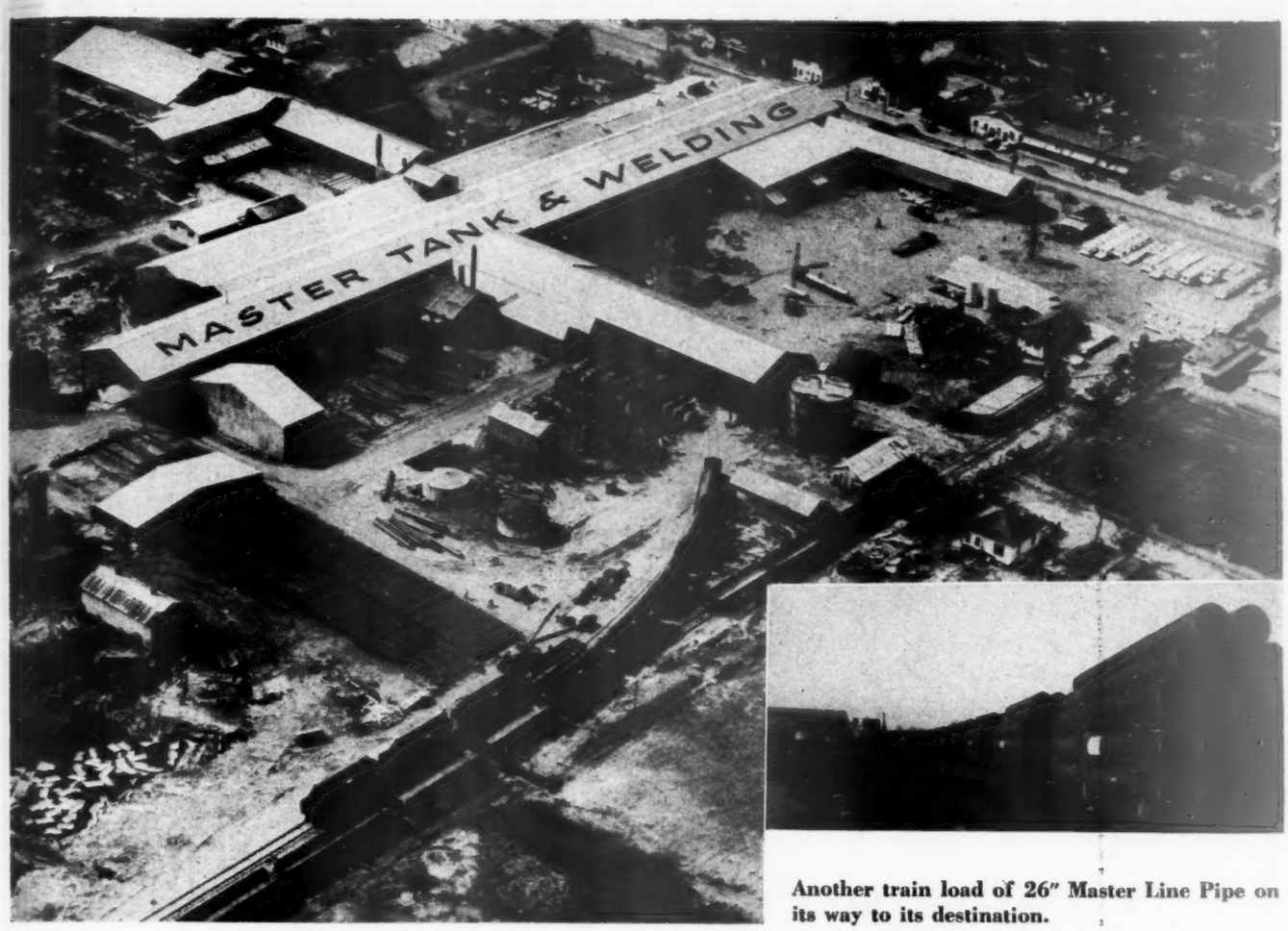
Treating solution piping.



Currently, because transportation facilities to the San Juan River Plant are somewhat limited, it is difficult to market all the liquid hydrocarbon product of the plant. El Paso Natural Gas Company is planning, therefore, to build a products pipe line from the San Juan River Plant to Gallup, a distance of about 115 miles, through which the gasoline, propane, and butane not sold locally can be pumped to the Santa Fe railroad mainline to be hauled to major markets.

The boiler plant at the San Juan River Plant is somewhat larger than the average natural gas treating plant boiler. It delivers 239,000 lb of steam per hour to reboilers at the purification unit. This steam leaves the boilers at 350 psi pressure but is put through turbines that drive the solution pumps and reduce to 125 psi pressure before being put into the reboilers. Steam is also used to generate electricity at the plant. As much steam as is necessary to fill requirements at the purification reboilers is reduced to 125 psi in the turbo-generators. The amount of steam to generate electricity over-and-above that required to operate the purification plant is reduced to 5-psi pressure.

The San Juan river plant has been in operation for about one year. During this time it has performed excellently. Employees of El Paso Natural Gas Company are proud not only of the plant's size but of its efficiency. * * *



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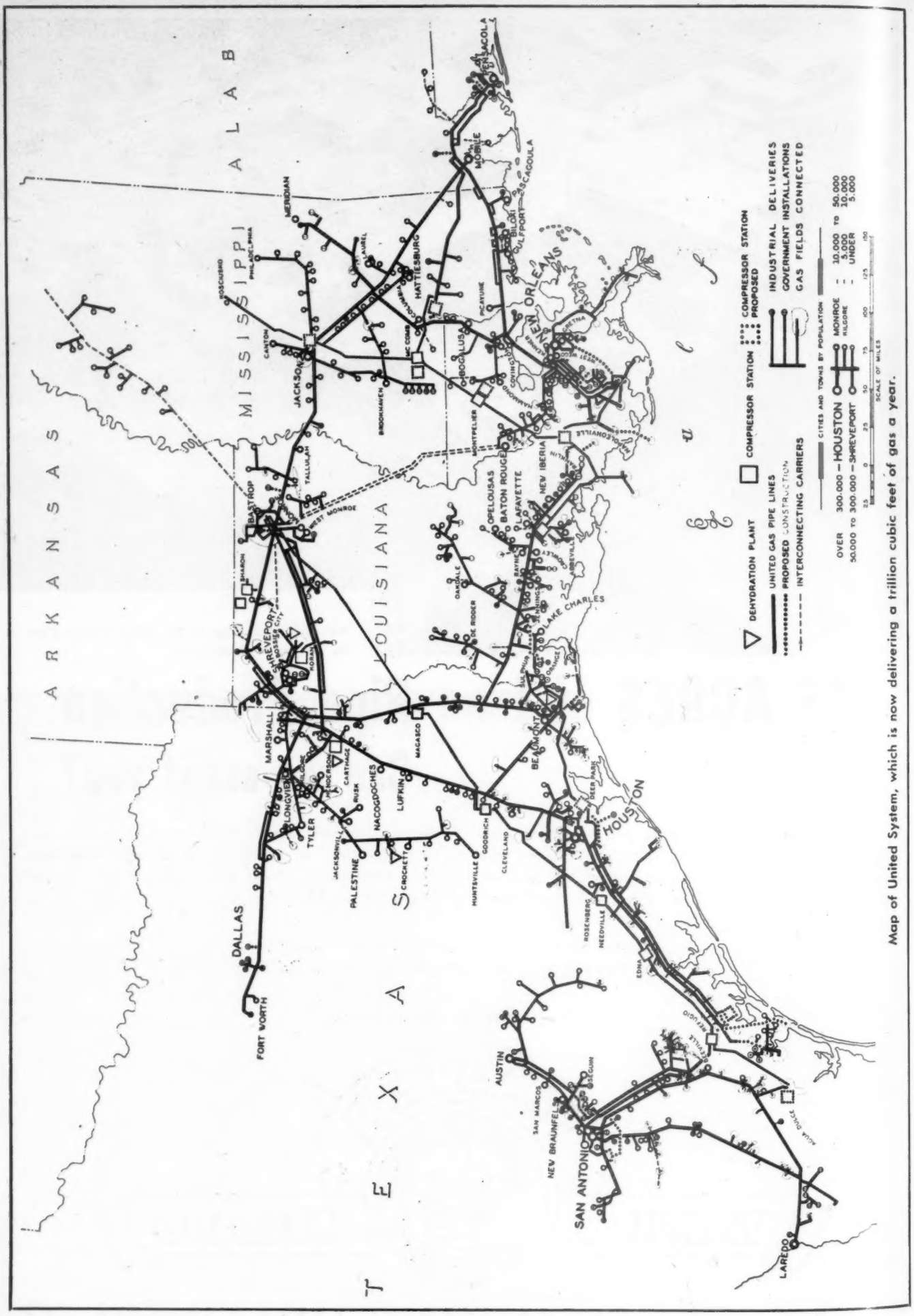
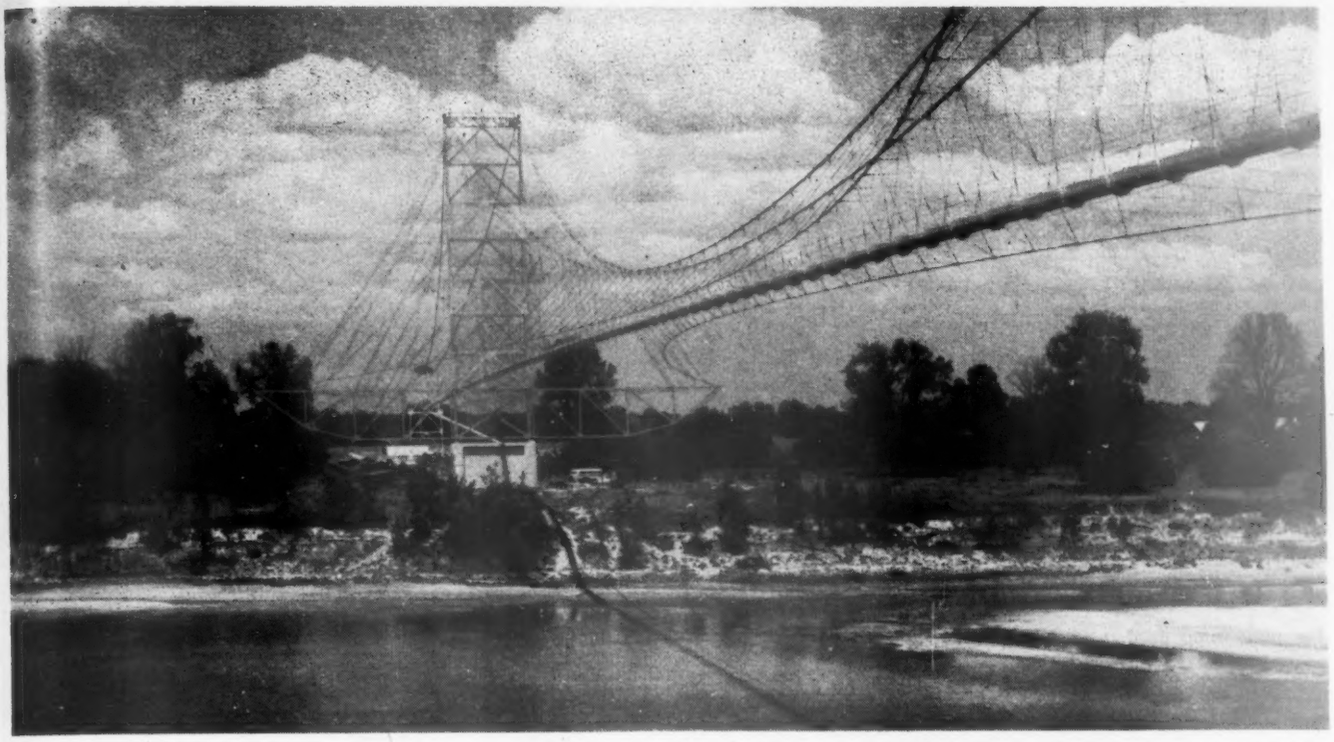


Map of United System, which is now delivering a trillion cubic feet of gas a year.



Red River suspension bridge near Natchitoches, Louisiana, is the longest of new overwater bridges — the main span being 1520 ft.

Trillion Cubic Foot Gas System

Expansion program, costing in excess of $200,000,000, places United Gas Pipe Line Company in singular category

FRANK H. LOVE*

FOREMOST among pipe line construction projects, in an era replete with outstanding accomplishments in this field, is the recent expansion program of United Gas Pipe Line Company. Requiring the greater part of two years to consummate, and costing in excess of $200,000,000, a program is nearing completion that involved the laying of some 1735 miles of pipe lines, the addition of 64,000 hp in new and enlarged compressor stations, the installation of large-diameter submarine pipe lines extending more than 25 miles into the Gulf of Mexico, and the construction of 11 dehydration plants.

This program has the effect of: (1) Providing greater capacity; (2) increasing the flexibility of the system, and (3) making available new reserves of natural gas.

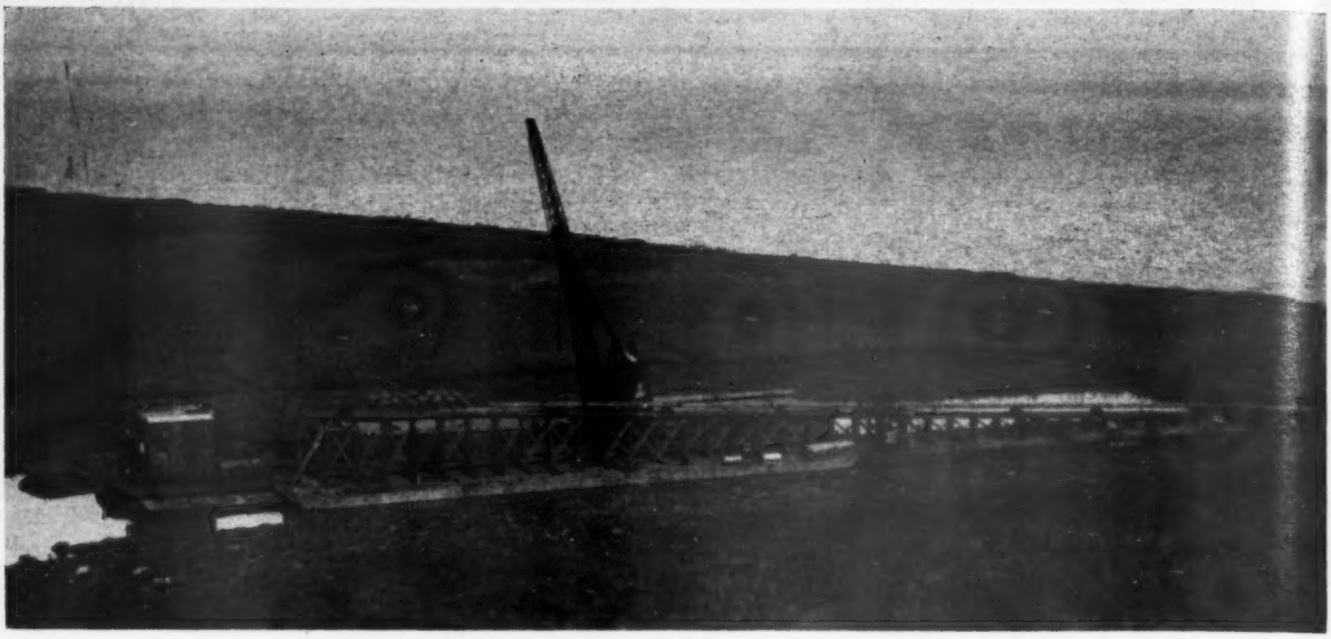
Maximum capacity of the system is thereby increased from 3,000,000,000 cu ft a day to 4,000,000,000 cu ft, which places United in the category of the first system having the pipe line capac-

*Editor, Oil and Gas Pipelining.

Upper Brazos River suspension bridge, 5 miles west of Rosenberg, Texas, is designed to carry two 30-in. lines, although only one has been installed.

EXCLUSIVE

Map of United System, which is now delivering a trillion cubic feet of gas a year.



The pipe ramp used in laying offshore line measured 670 ft from end to end.

Laying the final of three 20-in. underwater Mississippi River crossing lines at Modeste, Louisiana.

ity to deliver a trillion cubic feet of gas a year. Significant, too, because its effect industrially and otherwise will be far-reaching, is the fact that all this is within the boundaries of an area termed the Gulf South, which embraces major portions of Texas, Louisiana, Mississippi, the southern part of Alabama, and northwest Florida.

The pipe line project consisted of several major segments. One line reached far down the delta of the Mississippi River to increase the supplies available to the New Orleans area. Another supplemented the capacity of lines serving Houston. Still another bolstered the gas supplies in the Beaumont-Orange-Port Arthur triangle. A line between Mobile and Pensacola was looped to provide additional gas to the northwest Florida area. Gathering lines were laid in numerous gas fields to feed gas into the system. Over the whole, built like a grid to provide gas at Monroe, Jackson or wherever else it was needed, were nearly 1000 miles of large-diameter lines extending from south Texas and off the

Making a tie-in at road crossing in Louisiana.

Crossing cypress-studded Guadalupe River bottoms.

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Ask, too, about wheel-type 215 . . . special pipeline Trenchliner with 6 speeds (up to 11.2 RPM) on digging wheel; standard tractor-type crawlers (18" treads, lug-type shoes;) standard 55 h.p. diesel engine. Other Trenchliners: 3 ladder-type sizes, full crawler-mounted . . . and mobile, rubber-tired Trenchmobile.

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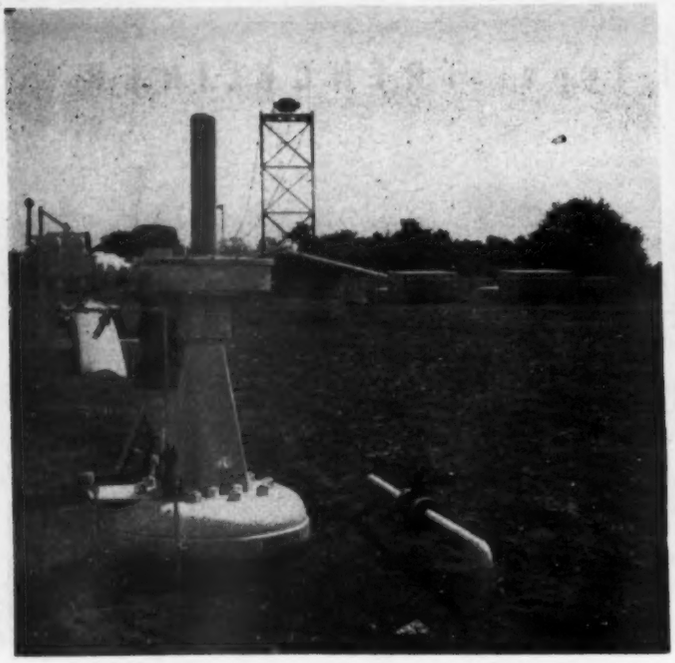
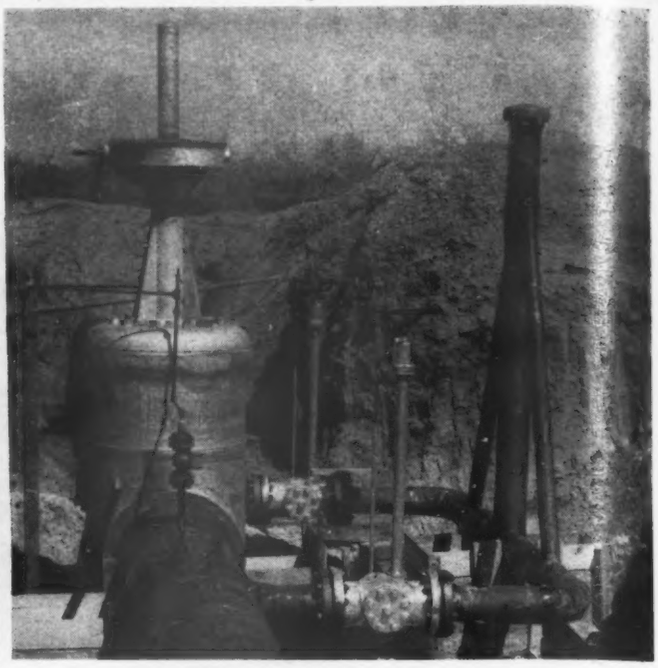
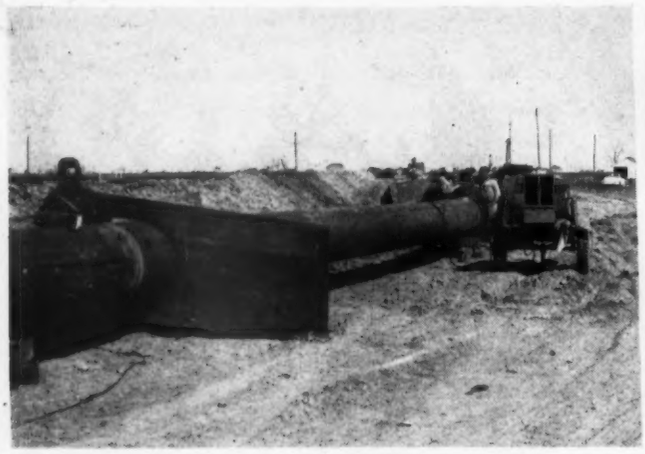


Motor-operated valve installed at suspension bridge over Colorado River near Wharton, Texas.



Thirty-inch valve and bypass at the San Antonio River crossing.



Firing line welders working behind shields to protect against dust.

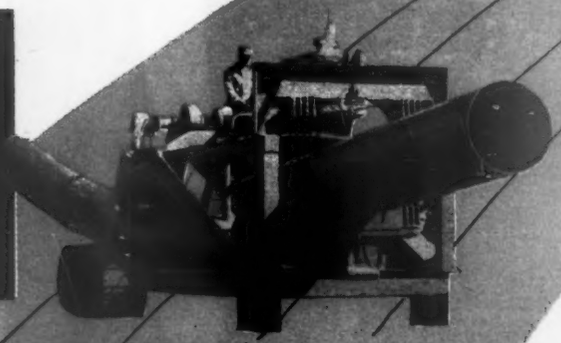
Coating yard at Many, Louisiana.

Cleaning out caved ditch with clamshells.

Ditching machine in operation near Victoria, Texas.

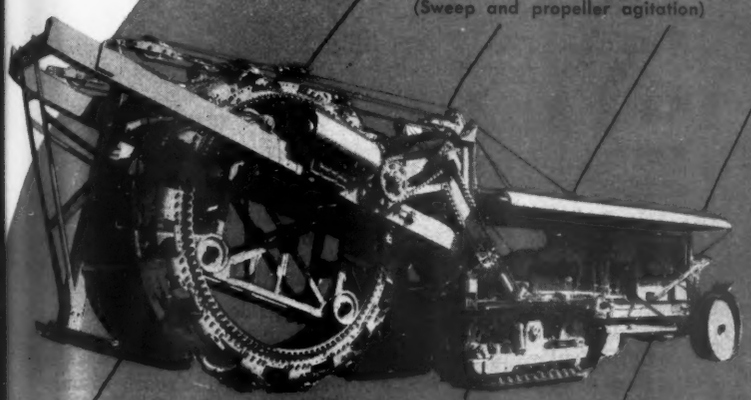
The New Designs Come From C-R-C

4 MAJOR DEVELOPMENTS within two years

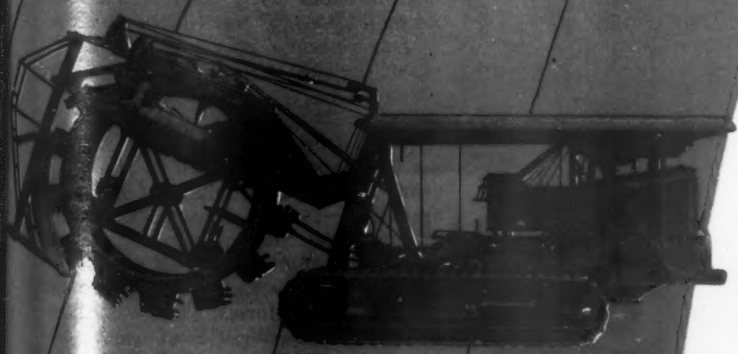


C-R-C Vertical Bending Machine for Pipe Sizes from 10" to 36".

C-R-C 27-Barrel "SP" Dope Kettle (Sweep and propeller agitation)



C-R-C "Big Inches" Ditching Machines for trench digging from 32" to 52" wide and 8' 6" deep.



C-R-C "Middle Inches" Ditching Machine for trench digging to 42" wide and 7' 6" deep.

There are even more C-R-C developments in the mill to speed up pipelining and cut costs. Watch for them. They are just waiting for the "JOB PROVED" tag to be hung on them.

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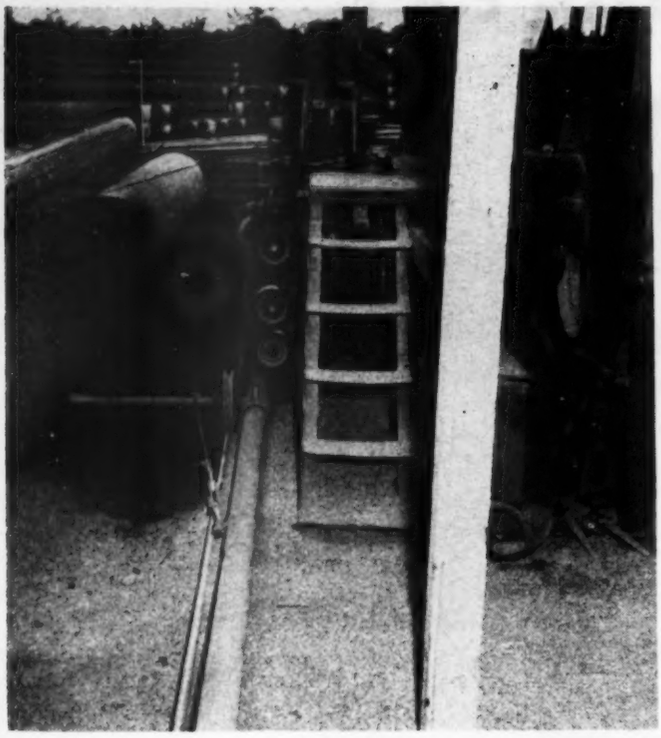
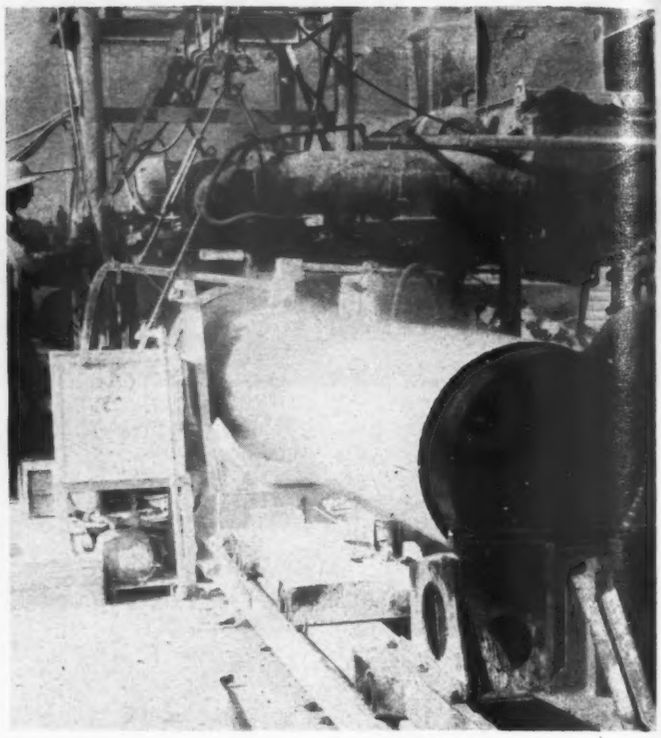


Applying concrete-type coating at Harvey, Louisiana, plant.



Applying asphaltic-mastic type coating to pipe at Morgan City, Louisiana.

coast of Louisiana to north Louisiana and north central Mississippi.

The enlarged system is now connected to more than 250 gas fields and serves some 460 towns and cities with natural gas, either wholesale or retail, as well as more than 2000 industrial customers.

This points up the remarkable growth of United since 1930, when the United Gas Corporation was formed by the consolidation of five major groups and more than 40 associated companies. At that time a system was formed that had 5700 miles of transmission, distribution, and field lines. Ten years later the total had grown to 11,260 miles, and by the end of 1951 to 18,500 miles.

In 1931, the first full year of operation, gas sales of the system totaled 155,000,000,000 cu ft. Sales in 1951 were 690,000,000,000 cu ft.

25-MILE SUBMARINE LINE

Possibly the most spectacular pipe line job of all time was the laying of large-diameter, heavily weighted pipe into the Gulf of Mexico off the coast of Louisiana, in water varying in depth from 2 to 20 ft. These were the first large lines to tap gas reserves in the Gulf, and are the longest gas pipe lines of any size laid off-shore.

Gas wells supplying the off-shore lines were drilled and are owned by Pure Oil Company, Magnolia Petroleum Company, and Sun Oil Company. All are in the Eugene Island area off St. Mary Parish, and are 15 to 30 miles off-shore.

From Pure's platform in Block 32, Magnolia's platforms in Blocks 51 and 95, and Sun's platform in Block 33, gas now flows to a United Gas platform, which has been erected near Pure's properties in Block 32, and thence through a 20-in. line to shore.

The 20-in. line extends from a point near Pt. Chevreuil, about 25 miles southwest of Morgan City, due south 15 miles to United's platform. A 14-in. line runs southwest to Magnolia's platform in Block 51, a distance of 10½ miles. A 10-in. line extends from Block 51 to Magnolia's location in Block 95, a distance of 12.71 miles. From Sun's platform in Block 33, a 10-in. line extends 1.4 miles west of the United platform.

Drama-packed as was the actual laying of the submarine line, the extensive preparations required before the first section of 20-in. pipe went into the water should not be forgotten. These preparations extended over a period of about a year. An important phase of the preparations was an exhaustive oceanographic study to provide an intimate knowledge of every foot of the underwater route between the shore line and the drilling platforms. Thus was understood the characteristics of waves, currents, water bottoms, shell reefs, and marine organisms before the project was undertaken.

The nature of the service for which it was to be used made it necessary that

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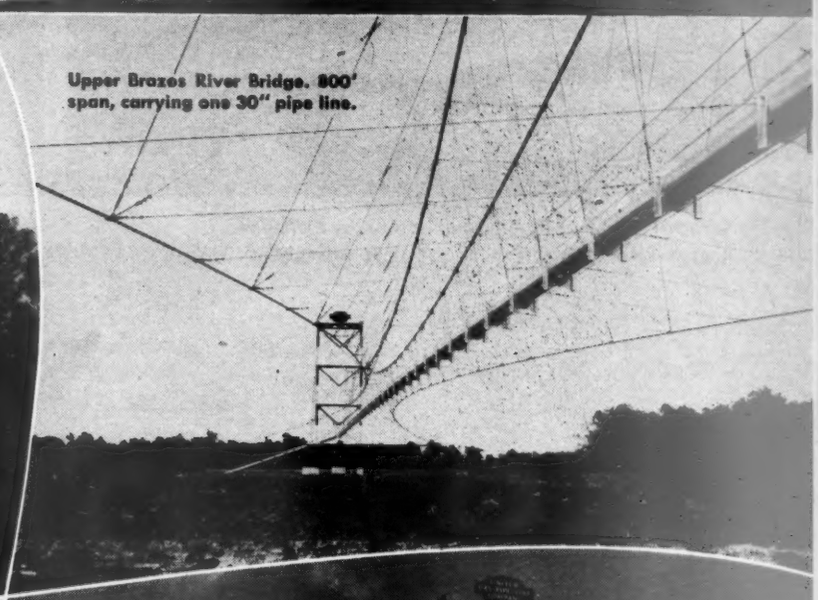
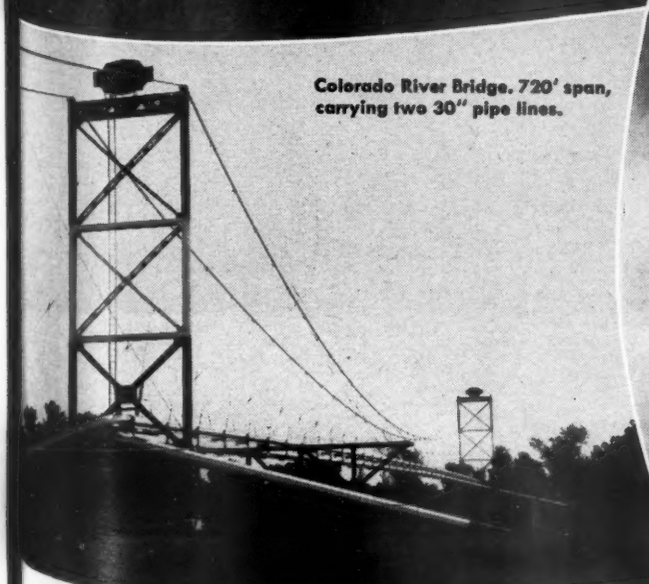
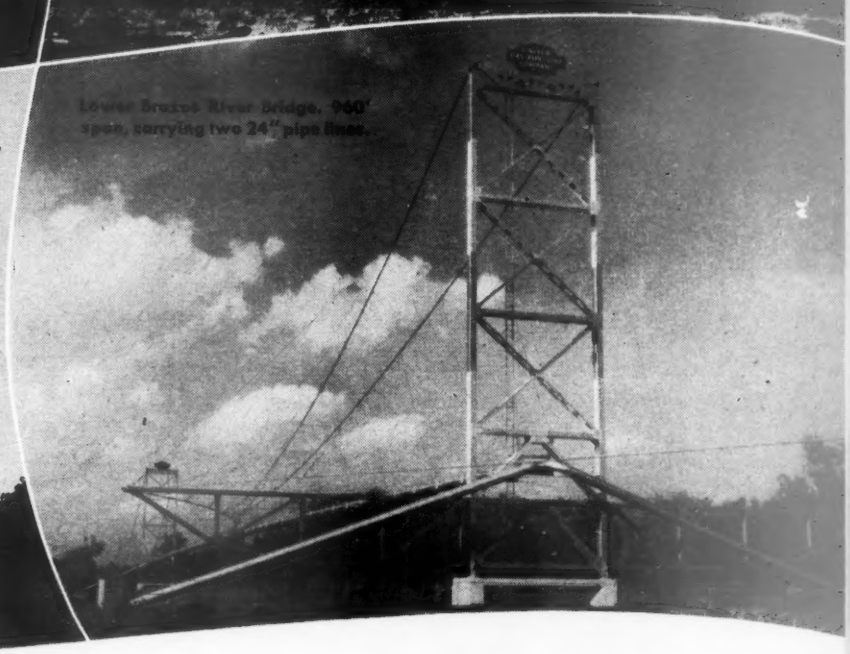
...d River Bridge. 1520' main span, with ...' side span. One 30" pipe line.



Upper Brazos River Bridge. 800' span, carrying one 30" pipe line.



Colorado River Bridge. 720' span, carrying two 30" pipe lines.



Lower Brazos River Bridge. 900' span, carrying two 24" pipe lines.

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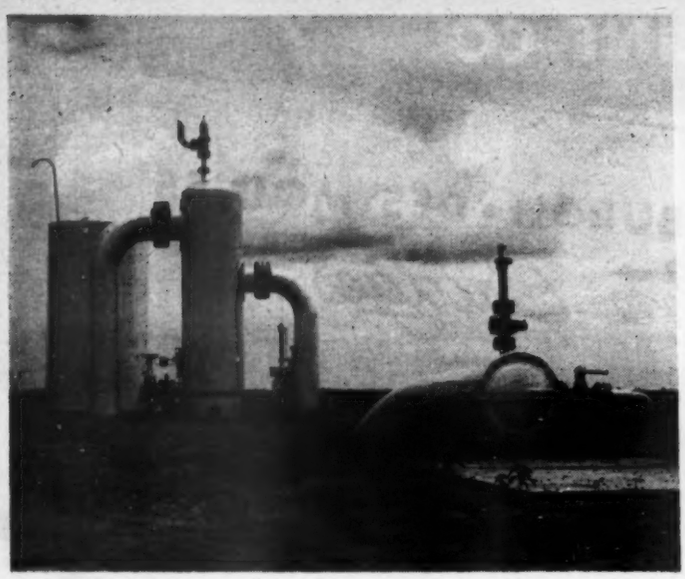
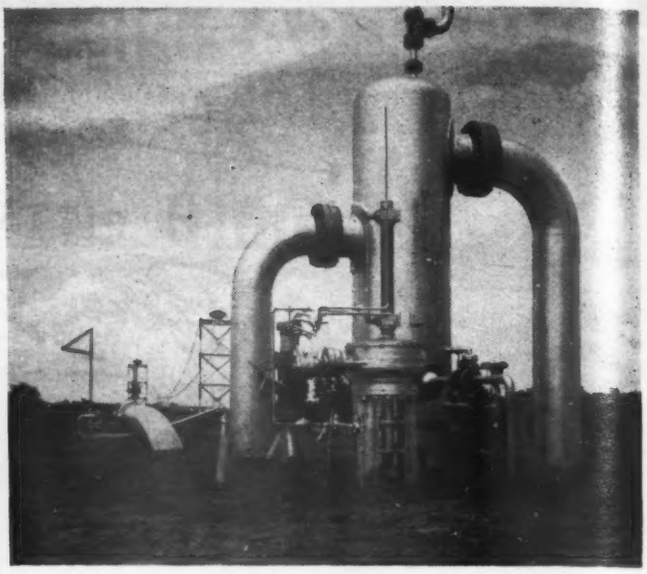
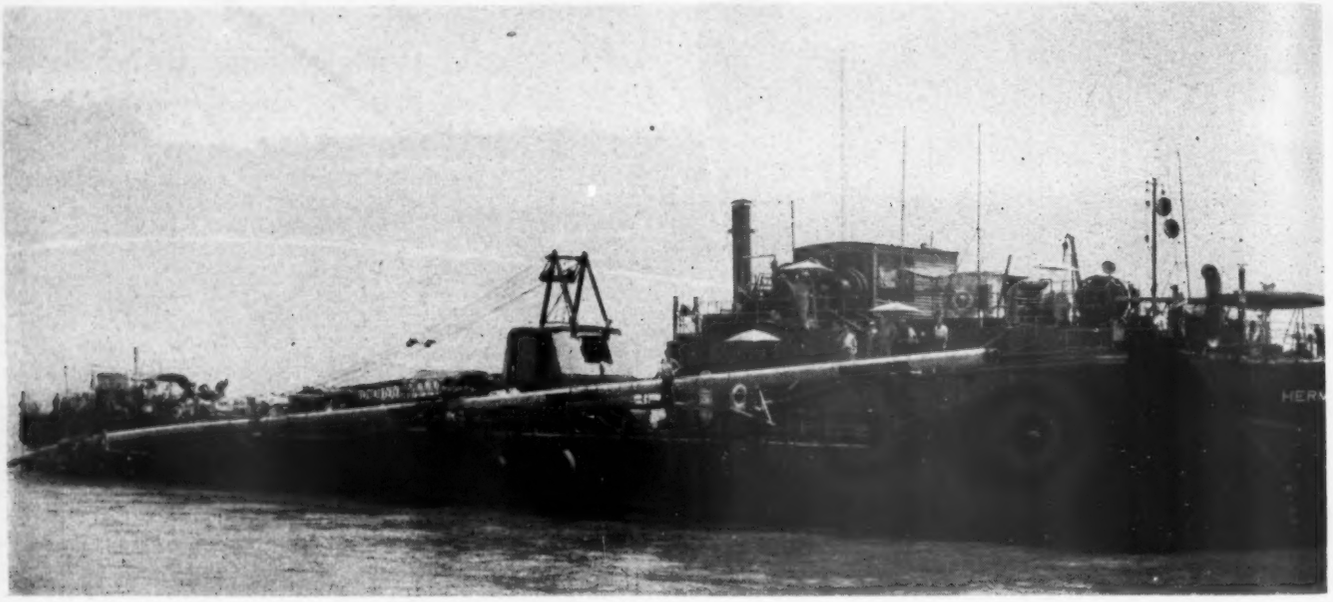


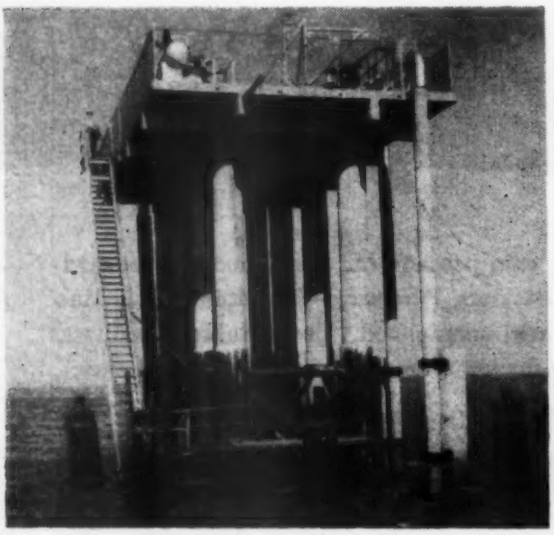
Scraper trap and liquid volume tank at the upper Brazos River suspension bridge near Rosenberg, Texas.



Liquid volume tank at upper Brazos River suspension bridge near Rosenberg, Texas.



Barge used to lay pipe 25 miles into Gulf of Mexico.



Offshore platform of United Gas in Gulf.

Pipe supported by pontoons moves seaward.

Progresssive pipe liners specify E-I-M valve controls

All Over The World

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the pipe be heavy and strong. The 20-in. pipe has a wall thickness of ½-in., and, in addition, a ¼-in. steel plate was wrapped around the pipe and welded. Then a ⅝-in. coating of asphalt-mastic was applied plus 1 in. of reinforced concrete. When ready for laying the pipe weighed 260 lb per foot.

The 20-in. pipe was coated and welded into five-joint, 200-ft sections at Bayou Boeuf near Morgan City and moved by barge to the launching site through the many canals and bayous that abound in this swampland area. The 14-in. pipe was coated, and most of it double-jointed, at a yard in Harvey, Louisiana, across the river from New Orleans, and then barged to the launching site.

To lay the 20-in. pipe from the shore to Block 32, a gigantic ramp was constructed, measuring 670 ft overall. On this ramp the sections of 20-in. pipe were welded together and from it the pipe was pulled into the gulf as each section was added. Anchored alongside the ramp, which sloped down to the water's edge, was a 100-ton derrick barge to handle the 200-ft sections of pipe, which weighed in excess of 25 tons each. From the derrick barge the pipe was lifted onto the ramp section by section and welded. When a section was welded and the joint coated, the winch barge anchored at sea on the head of the string of pipe was notified by radio, and its huge winch, capable of pulling 155,000 lb, moved the long string of pipe ahead 200 ft, then stopped awaiting the next section. Pontoons were attached to the pipe approximately every 500 ft to float the line and enable it to be pulled more easily. On the ramp, the pipe was strapped in saddles on dolly cars that traveled on narrow-gage steel tracks, making it possible to launch the pipe without damaging the coating. Welding was from a special platform midway up the ramp.

The 20-in. pipe was pulled seaward in seven sections, the first some 23,000 ft long and the others ranging in length from 7500 to 11,500 ft. The winch barge was equipped with anchors and spuds to hold it in position while pulling. Once made stationary, 600 ft of pipe was pulled before the barge was again moved ahead. A tugboat provided the motive power for moving the barge.

The 14-in. line extending on to Magnolia's platform was laid in a different manner. This 10½ miles of pipe was "stove-piped" from a 260-ft by 50-ft converted naval barge. In converting it to a pipe laying barge, four structural steel working platforms, inclined from bow to stern, were built out over the side of the vessel to handle the pipe. From pipe barges anchored alongside the laying barge the pipe was fed joint by joint onto the inclined platforms and welded. The laying barge was equipped with eight anchors of the 3000 to 5000-lb class, which were attached to steel cables extending from winches on the deck. By such means the pipe laying barge could pull itself forward as each joint of pipe was welded.

This pipe also has a wall thickness of ½ in., to which a ½-in. thickness of mastic coating was added, then 1 in. of reinforced concrete coating, giving a total weight of 140 lb per foot.

The 10-in. lines were laid from floating equipment in much the same manner as the 14-in. They had a wall thickness of ½-in. and were given coatings of primer, enamel, and wrapper.

A concrete platform was erected 1000 ft northwest of Pure's Block 32 platform, standing 40 ft above the water and resting on eight concrete piling that are sunk deep beneath the floor of the gulf. This serves as the hub from which various lines extend to the producing platforms. Two 14-in. lines connect United's platform with that of Pure. After the tie-in was made both the 20-in. and 14-in. lines were jetted down beneath the floor of the gulf to their permanent depth by hydraulic pumps, the specified cover being 3 to 6 ft.

From the shore line the 20-in. pipe extends approximately 3 miles through marshy country to Burns on Bayou Sale, where the pipe size becomes 26 in. At Bayou Sale Junction, 13½ miles farther north, the 30-in. pipe line begins.

LINE CONSTRUCTION

Other than the offshore construction outlined, the general topography of the area through which the lines were laid varies from level to rolling. Numerous types of terrain are found, however, and

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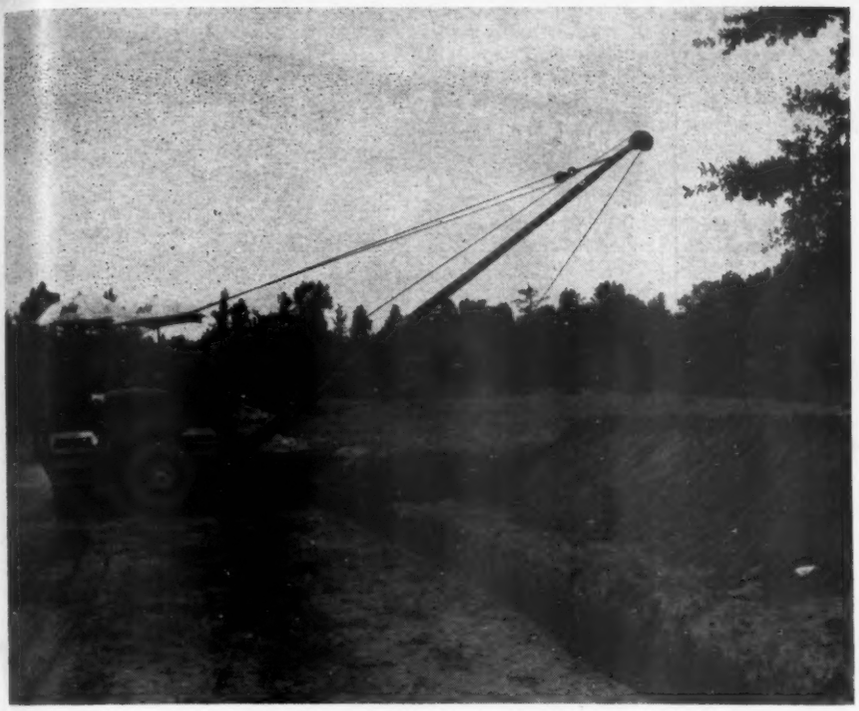

Backfilling the ditch in Louisiana.

Bending a joint of pipe.

the most difficult, and the one requiring the greatest degree of engineering ingenuity, was the marshlands bordering the Gulf of Mexico in South Louisiana. Through this area approximately 200 miles of pipe line was laid. In a considerable portion of the marshlands the water is too deep for the operation of conventional pipe line equipment, and too shallow for the use of boats. To solve this problem much of the pipe was laid progressively from barges in canals made by dredges. Another method was to shove the pipe through a ditch made by draglines. All pipe laid in such areas was given a coating of asphalt-mastic and/or concrete to provide weight and protection. Under conditions requiring canal construction it was necessary to provide a 100-ft wide right-of-way. Under normal overland conditions, however, a 75-ft right-of-way was sufficient for all activities.

Normally the dimension of the ditch was such as to provide 30 in. of cover and in width 12 in. greater than the outside diameter of the pipe. Water crossings were an exception. When crossing waterways or open water that were under the jurisdiction of the U. S. Corps of Engineers, drainage boards, or other agencies, regulations of those bodies

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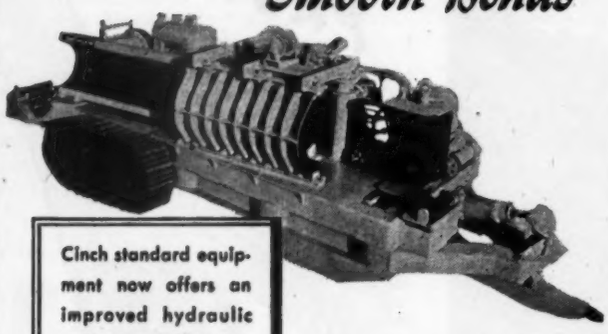

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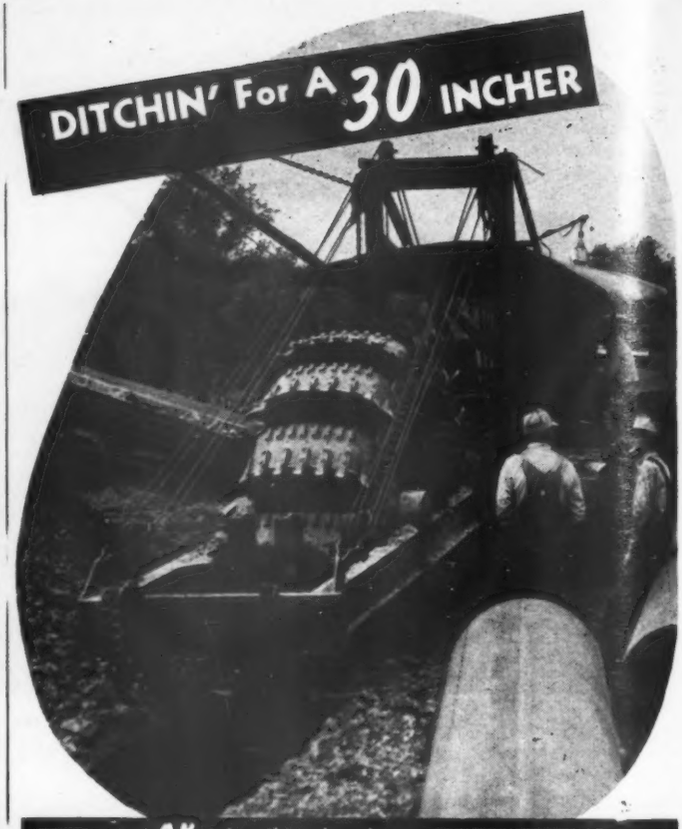

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Coating pipe in the yard at Refugio, Texas.

were observed regarding the depth to which the lines must be buried. Also, lines laid in canals were buried below the bottom of the canal to make it possible to use these waterways for future maintenance.

As mentioned, asphalt-mastic coating was used to protect the pipe in swamps and marshes and offshore. On overland sections otherwise a prime coat, hot enamel, and glass and asbestos felt wrappers were applied to the pipe.

For underwater river lines coating specifications were more rigid. First a coal tar primer was applied, then coal-tar enamel, glass fiber wrapper, coal-tar enamel again, and finally an asbestos felt wrapper. Additionally, a concrete coating was used on some of the crossings. Further protection against corrosion will be provided by rectifiers.

Such an extensive program, obviously, justified extreme care in the matter of welding. As all welds were made manually, welders were given a rigid qualification test, and their welds inspected by X-ray both at the time of the test and on the right-of-way later for those who qualified. The electrodes used were AWS classification E6010 and E7010.

The lines were cleaned internally with brush type "Pigs," before being tested with gas for leaks and maximum working pressure prior to being placed in operation.

Scraper traps have been installed at all stations, at some multiple stream crossings, at suspension bridges, and at some of the mainline valves.

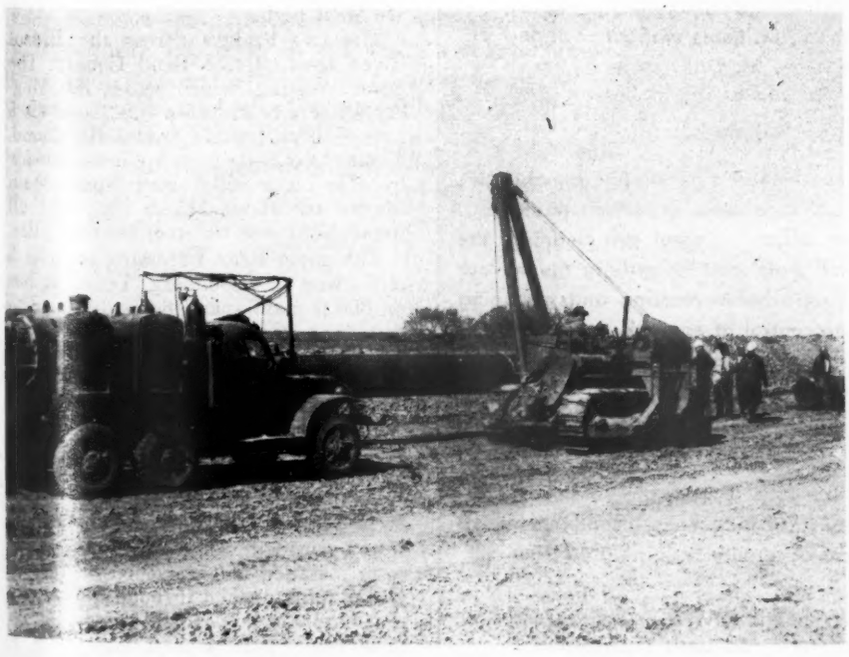
Mainline valves, installed at approximately 10-mile intervals, are full opening, full-line-sized, of both the through-port and gate types. On all mainline gate valves gas-driven motor operators have been installed.

RIVER CROSSINGS

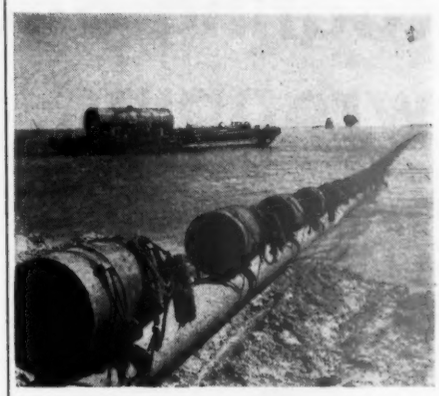
Twelve major underwater river crossings and five suspension bridges were installed as a part of this project. Underwater crossings were of three types, depending principally upon required capacity. In some instances there were three 20-in. lines, with one bowed upstream, one downstream, and one straight across the river channel. When two 20-in. lines were used, one was bowed upstream and one downstream. At some minor river crossings the main 30-in. line was looped with a single 20-in., both lines being laid straight across the channel.

The following crossings required multiple lines consisting of three 20-in: Mississippi River at Donaldsonville, Louisiana; Pearl River near Sharon, Mississippi; Amite River at Port Vincent, Louisiana; Trinity River near Shepherd, Texas; Sabine River near Hemphill on the Texas-Louisiana line;

Lining up for a tack weld on Texas spread.



THIS WATE-KOTED PIPE

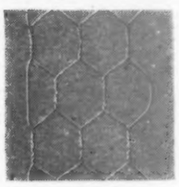


WILL SOON BE ON BOTTOM... TO STAY ON BOTTOM!

Whether your next job will be similar to the one illustrated above—laying pipe through open water, or through rivers or marshy ground, WATE-KOTE will do the job better.

WATE-KOTE is the high-strength, high-density weighting material developed by Rosson-Richards to lick the toughest weighting problems at minimum cost. WATE-KOTE is not only the heaviest weighting material of its type yet developed, but is tough enough to take a lot of punishment during laying operations.

WATE-KOTE is uniformly reinforced with Key Mesh Wire or Single Strand Wire to provide an adherent material almost as strong as the pipe itself.



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Ouachita River and Bayou D'Arbonne, both near Monroe, Louisiana, and Guadalupe River southwest of Victoria, Texas.

Two 20-in. lines were installed on a bridge over the Pearl River at Pickwick, Mississippi.

Single 20-in. lines laid to loop the main 30-in. were installed as follows: Neches River near Smith Ferry, Texas, and Angelina River near White City, Texas.

Across Six Mile Lake near Morgan City, a single 30-in. line was laid.

The Mississippi River crossing was laid from a ramp barge. A section of the barge from which the 20-in. offshore line was laid was utilized for this purpose. The rest of the rivers are not navigable at all times, and in these instances the pipe was pulled into place.

The five suspension bridges were of the Brazos River, crossed twice, and the Colorado in South Texas, the Pearl River in Mississippi, and the Red in Louisiana.

The longest of the five crossings is that of the Red River near Natchitoches, Louisiana. Its main span stretches more than a quarter of a mile, 1520 ft to be exact, with a side span on the north side of the river of 760 ft. The bridge carries one 30-in. pipe line. All foundations rest on steel bearing piles. The main towers are 175 ft high. The superstructure is carried on two main cables, each made up of two galvanized bridge ropes. These cables, as well as those on other suspension bridges, were prestressed to 50 per cent of their ultimate strength.

The Pearl River crossing is situated about 25 miles south of Jackson near Hopewell, Mississippi. Its main span measures 500 ft.

The Colorado River bridge a few miles downstream from Wharton, Texas, carries two 30-in. lines saddled one above the other. One of these lines carries gas on the new Agua Dulce-Monroe system, the other is on the Magnet-Withers to Houston line. The main span of this bridge is 720 ft. The main towers are 90 ft high.

The two bridges across the Brazos River are in Great Bend County. The lower crossing, which serves the Magnet-Withers to Houston line, is about 5 miles downstream from Richmond, Texas. Two 24-in. lines are installed side by side on a 960-ft main span. Main towers are about 115 ft high and all foundations rest on steel bearing piles.

The upper Brazos crossing is about 5 miles west of Rosenberg, Texas. It has an 800-ft main span and is designed to carry two 30-in. lines, although at present there is only one line installed. The towers are 100 ft high and the superstructure is carried on two main cables, each made of two galvanized bridge ropes.

At all overhead suspension bridges, and at multiple line underwater crossings requiring headers, scraper traps were provided. Liquid volume tanks were installed at suspension bridges to trap liquids pushed through the line by the scrapers, thus avoiding imposing an unnecessary load on the bridge. * * *

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permits stop-off for processing or storage at St. Louis without freight penalty. When you ship through the St. Louis gateway, you enjoy "through freight rates" instead of the higher combination rates generally used.

standard pipeprotection inc. procedures include pipe storage on rail-skids above ground... pipe handling on skidways and spoolways to prevent damage... exact temperature control in all areas of our plant . . . steel grit cleaning, the best accepted method for removing rust and mill scale, and for etching the surface to provide maximum bond . . . warm primed pipe before coating and wrapping to assure maximum bond . . . rigid temperature control of enamels during melting and application to eliminate formation of carbon or coke . . . inspection of every length of pipe with electrical holiday detectors . . . loading of coated pipe, nested in pyramids, excelsior padded, strapped into one unit, and protected from dirt, cinders, and weather by reinforced paper covering to meet A. A. R. specifications.

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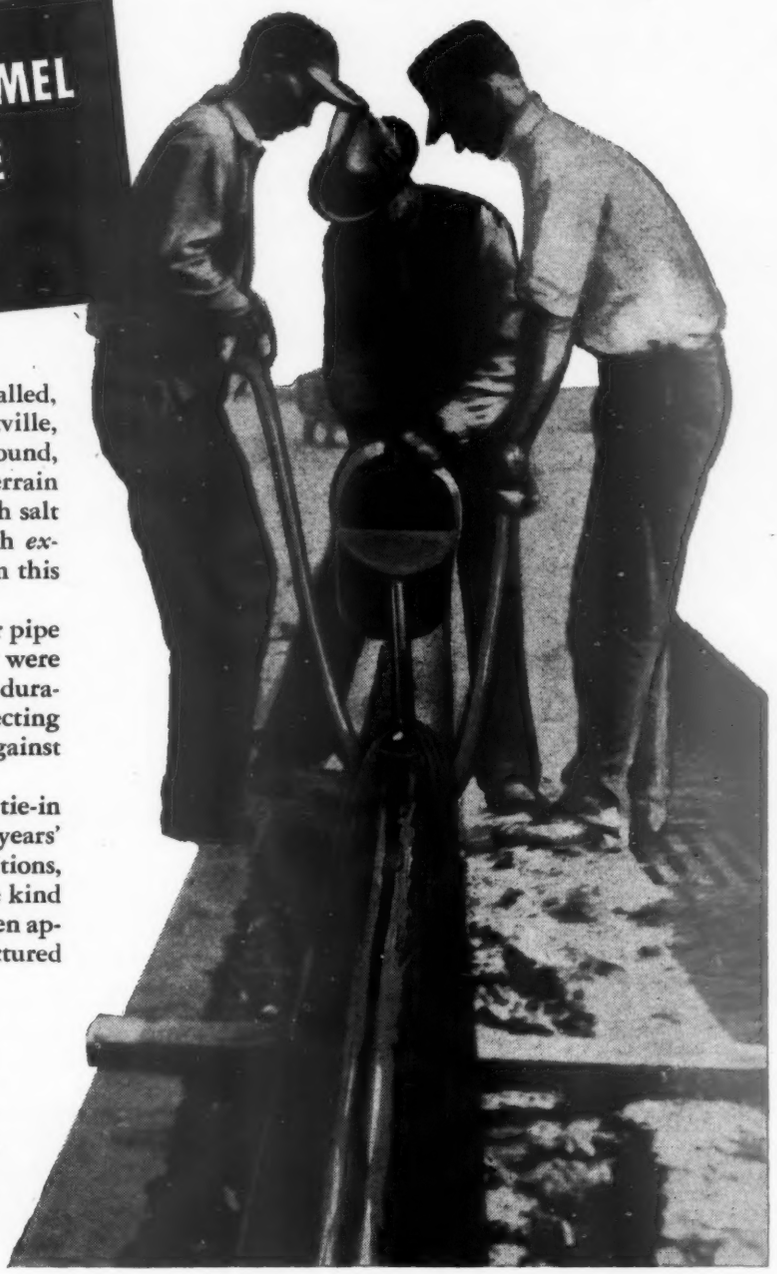

IN 1926, a 6-mile, 8-inch gas pipe line was installed, extending from Atlantic City to Pleasantville, N. J. This line was laid about two feet underground, in land known locally as "the meadows." The terrain is tidal marsh and high tides flood the land with salt water. No steel pipe line, unless provided with *exceptional* protection, could possibly last long in this corrosive soil.

The owners knew this and therefore had their pipe line protected with Bitumastic Enamel. They were influenced, to a great extent, by the fact that this durable enamel had already proved its value by protecting ships and large-diameter steel water lines against corrosion.

In 1951, a pipe section was removed so that a tie-in could be made with another pipe line. After 25 years' exposure to tidal marsh and sea-water conditions, there wasn't a sign of corrosion. This shows the kind of protection Bitumastic Enamel gives, even when applied by the old-fashioned manual method pictured here.

Today, of course, gas and oil pipe lines are cleaned, primed, coated and wrapped mechanically. Further—improvements have been made in Bitumastic Enamels in the last 25 years. Give your next pipe-line project *lasting* protection against corrosion by specifying Bitumastic Enamels. Your Koppers representative will give you complete details and estimates.

Photograph made in 1926 shows gas pipe line (Atlantic City—Pleasantville) being coated with Bitumastic Enamel. A single coat of enamel was applied by the "Sling Method" to a minimum 1/16" thickness. In 1951, a pipe section was removed so that a tie-in with another line could be made. An examination revealed no sign of corrosion.

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General view of the McComb, Mississippi, compressor station.

P 620.

Compression and Dehydration

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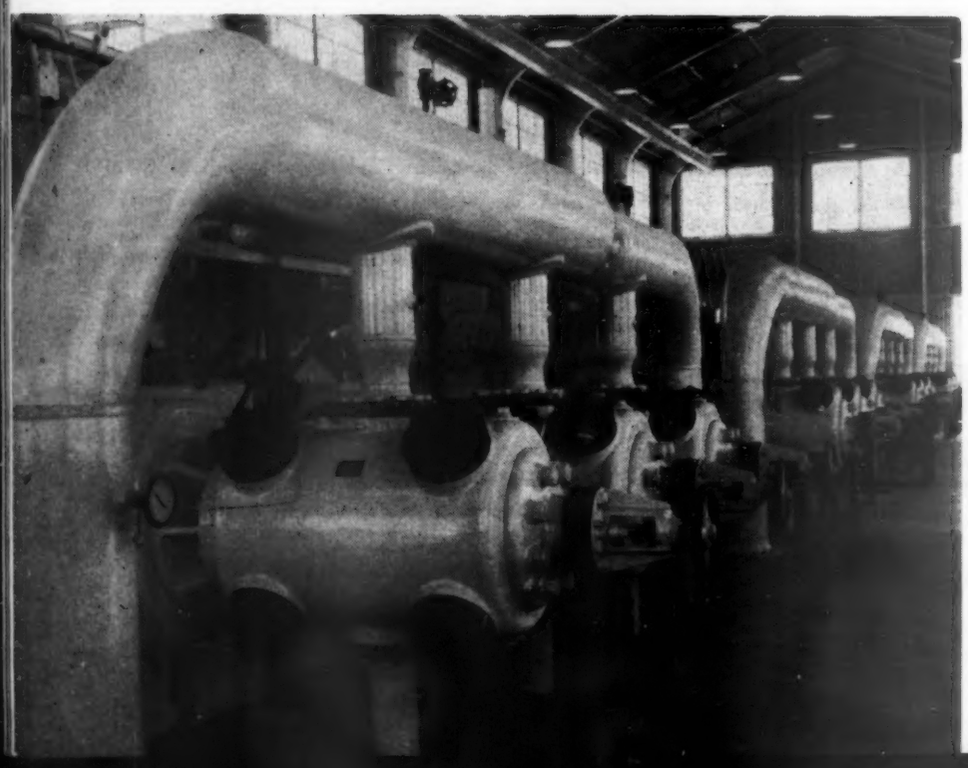
FRANK H. LOVE†



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By building eight new compressor stations and enlarging another in its expansion program United Gas Pipe Line Company has increased its horsepower by 64,000. This virtually doubles its previous compressor capacity.

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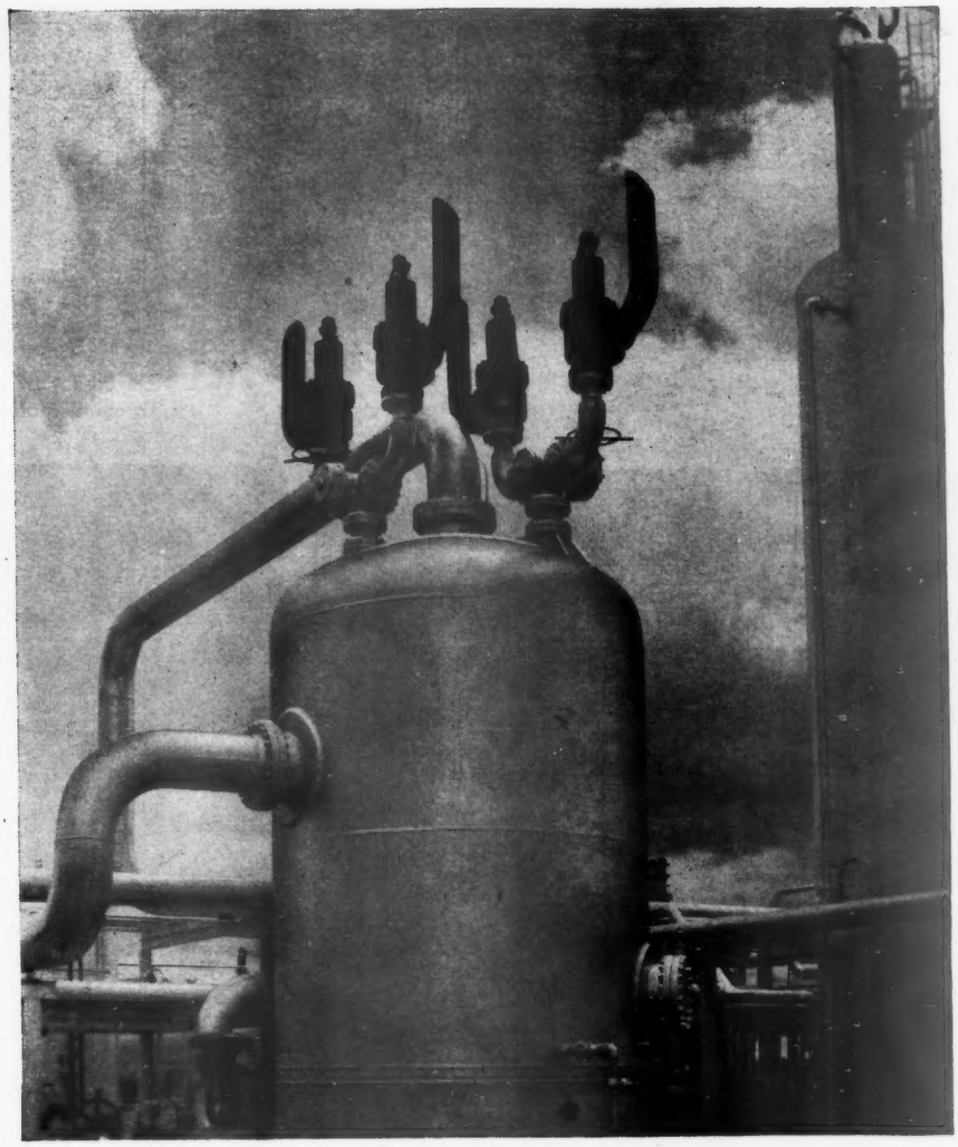
Refugio, Texas	12,000 hp
Edna, Texas	12,000 hp
Needville, Texas	7,920 hp
Goodrich, Texas	7,920 hp
Magasco, Texas*	2,000 hp
Lafayette, Louisiana	4,400 hp
Montpelier, Louisiana	8,000 hp
McComb, Mississippi	8,000 hp

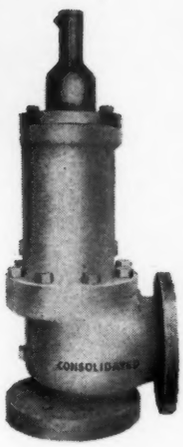
*Enlargement.

†Editor, Oil and Gas Pipelining.

Angle type compressors in the Lafayette station.

Consolidated Safety Relief Valves installed on main scrubber at Stanolind Oil & Gas Co., Stano, Kansas.





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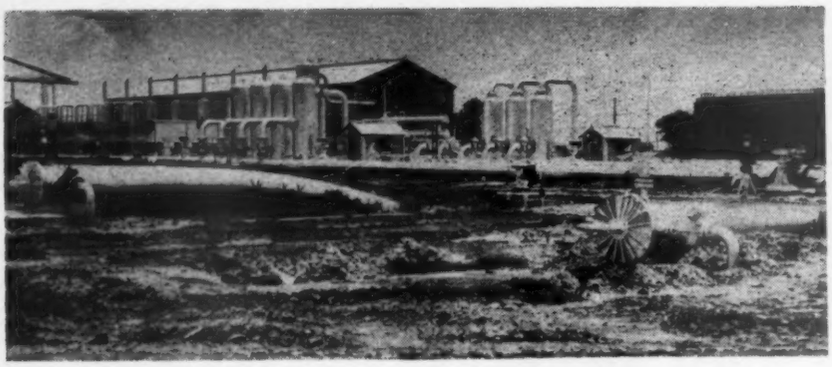
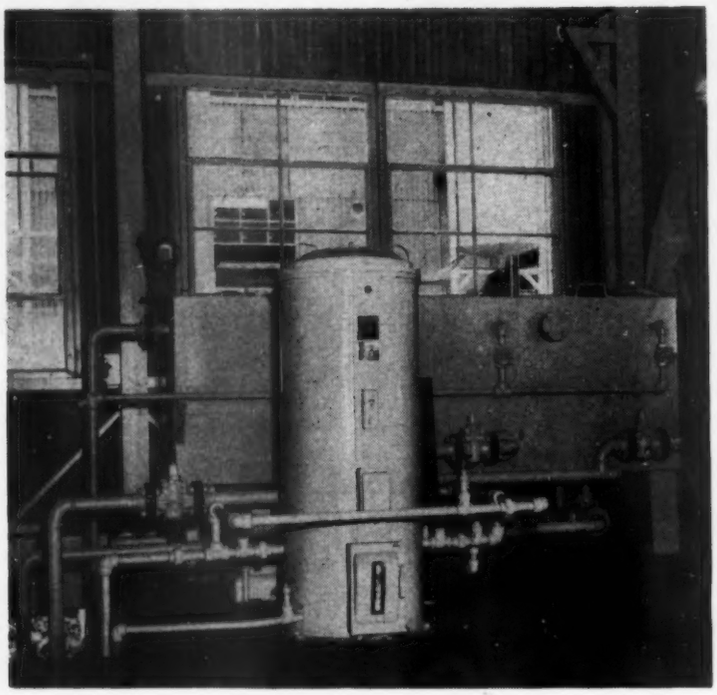
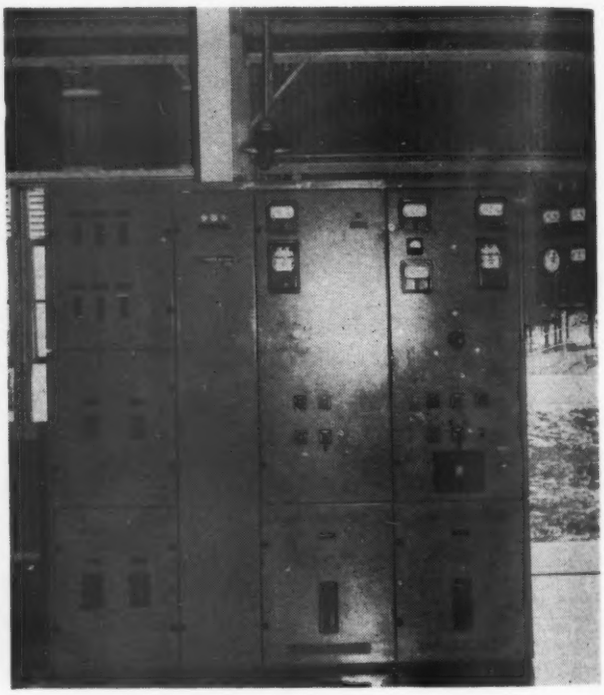


Scraper traps at Edna station.

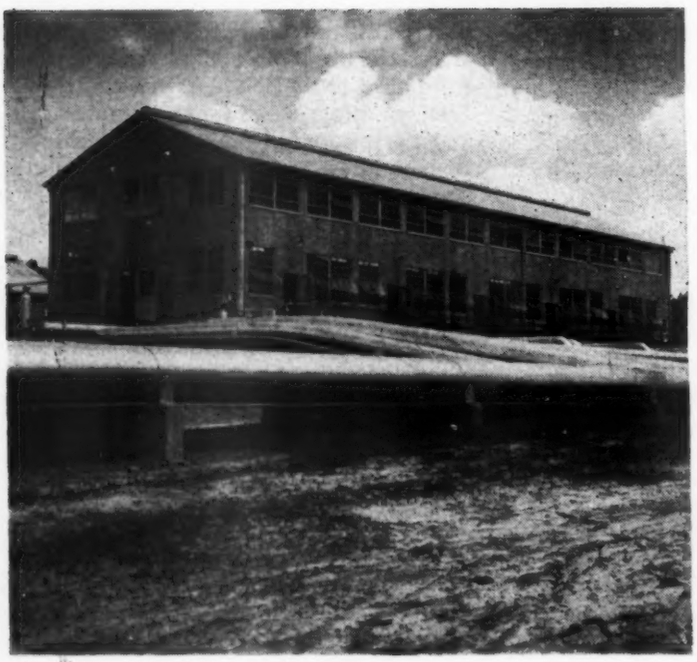
Elevated view of fin-fan coolers at Lafayette station while under construction.



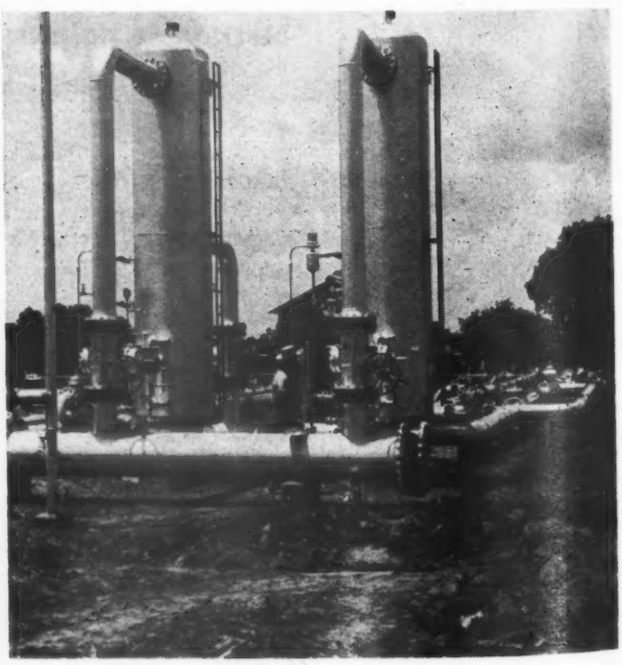
Crankcase oil reclaimer.



Switchgear for generator and power lines, McComb.



Main compressor building at McComb.



Inlet scrubbers at Lafayette.

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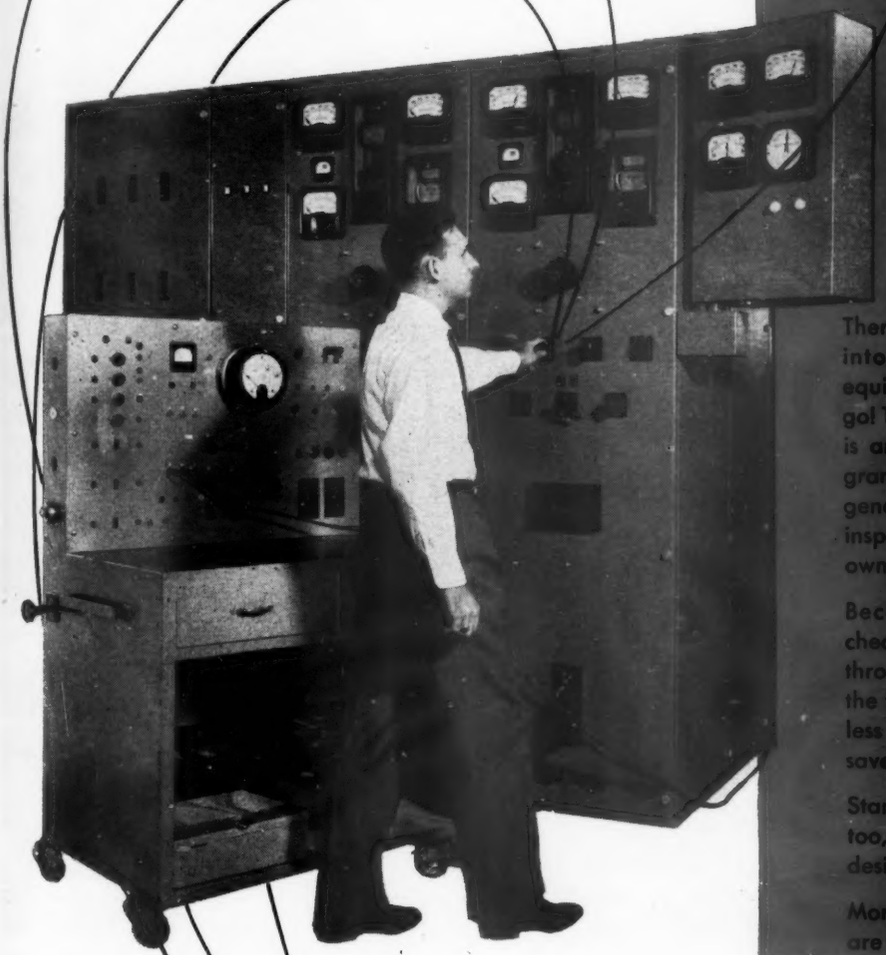

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There's little or no field problem of getting into operation with Standard Electric equipment. Wire it in and it's ready to go! The secret of Standard's dependability is an *unusually rigid* factory-testing program. At left you see a Standard Electric generator control panel getting its final inspection on testing equipment of our own, *exclusive* design.

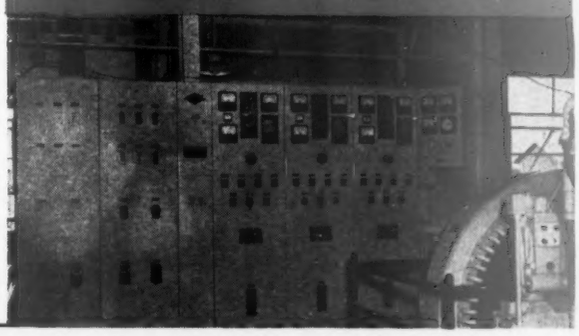
Because of Standard's never-ending checking and double-checking procedures throughout assembly, installation men in the field are saved endless hours of needless adjustment trouble . . . plant owners save untold dollars on labor costs.

Standard is easy to handle and service, too, because of the "Stressed-Skin" cubicle design (another Standard exclusive).

More and more engineers and operators are specifying Standard Electric on new installations.

AT RIGHT—

Standard Electric Generator Control Panel at a Southern Texas Substation of a Major Gas Pipe Line Company.



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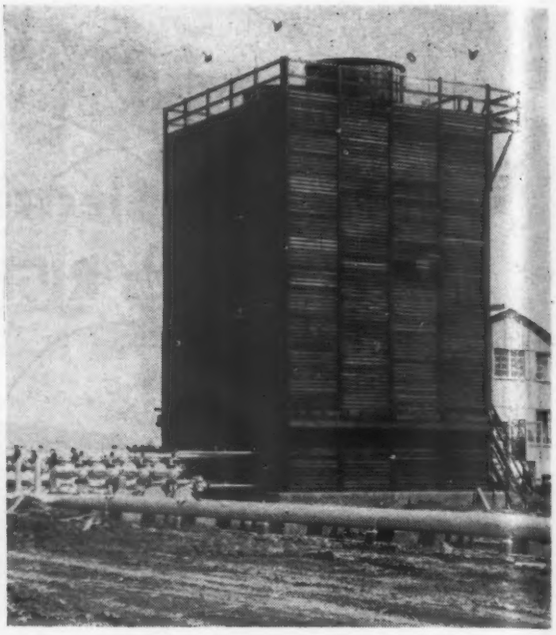
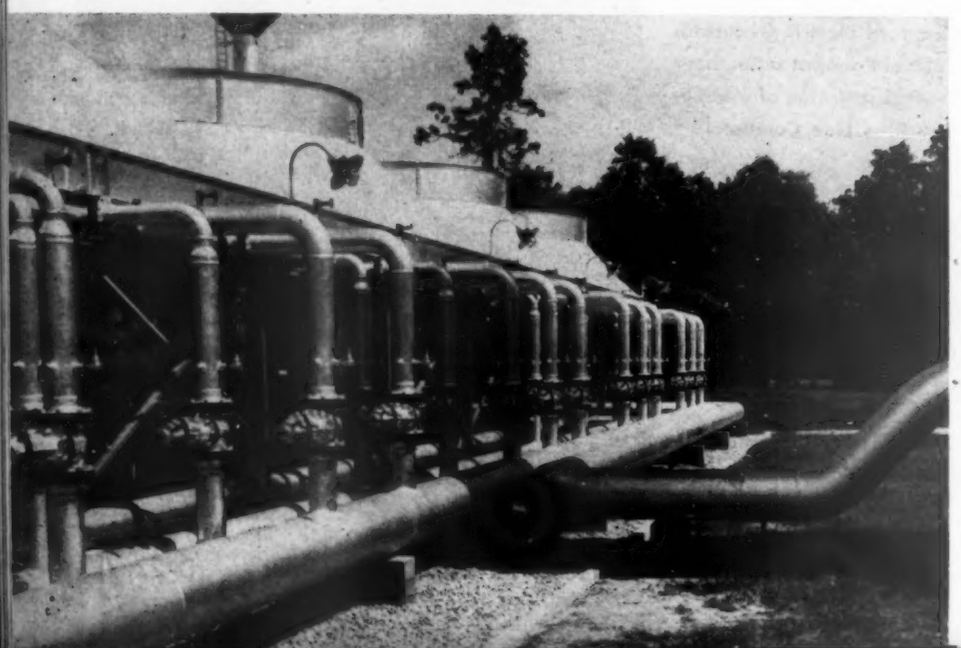
Dehydration plant at Refugio station.



Cooling tower installation at Lafayette, Louisiana, compressor station.

Fuel run to engines at McComb, Mississippi.

Below, row of valves on lines to fin-fan coolers.



The Agua Dulce station, near the origin point of the line, has four 440-hp package-type compressor units. Each unit is a complete compressor plant within itself. Radiator-type cooling is employed, there being a separate radiator for each engine. Approximately 200,000,000 cu ft of gas daily will enter this line. Of this volume, 30,000,000 cu ft is received from the company's Agua Dulce gasoline plant at a pressure of 425 psig, and 45,000,000 cu ft from low pressure wells. The pressure of this gas is boosted to 700 psig by the new station. The remaining 125,000,000 cu ft is from high pressure gas wells and does not require compressing. Consequently, this gas bypasses the station and joins the compressed gas on the

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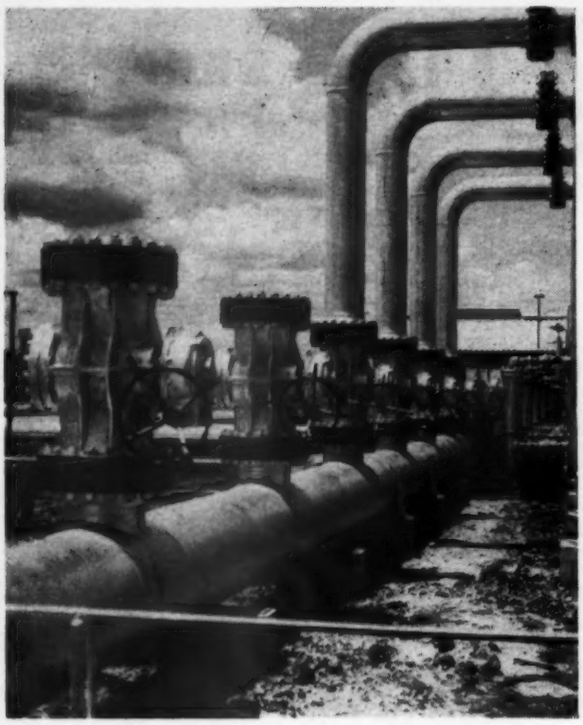
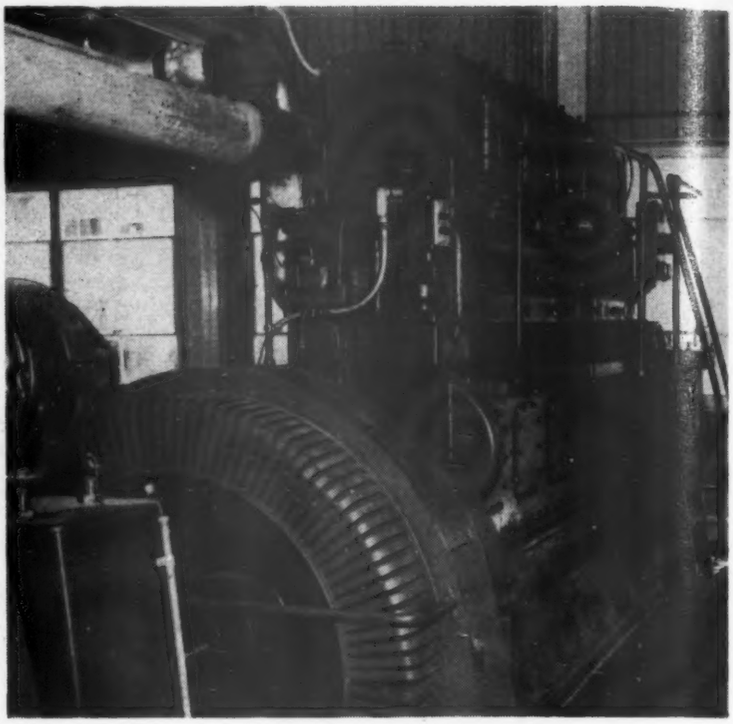
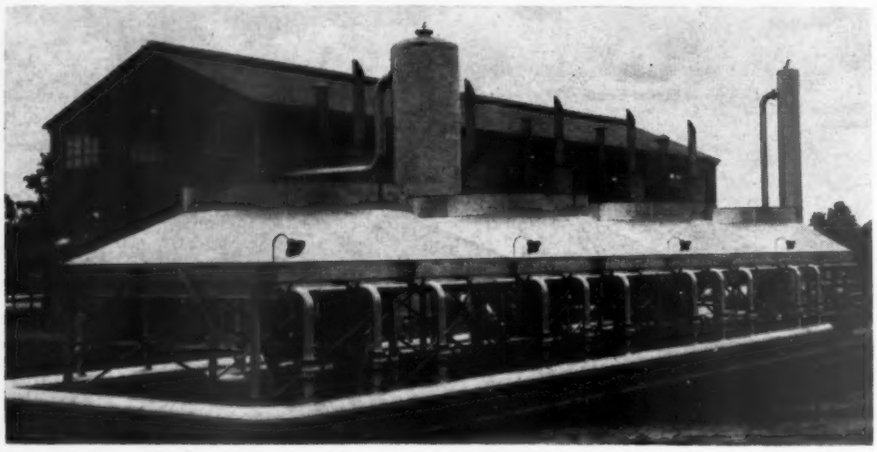


Motor-operated valves on scrubbers at Edna station.



445-bhp, 4-cycle gas engine driving 375-kva generator at McComb.

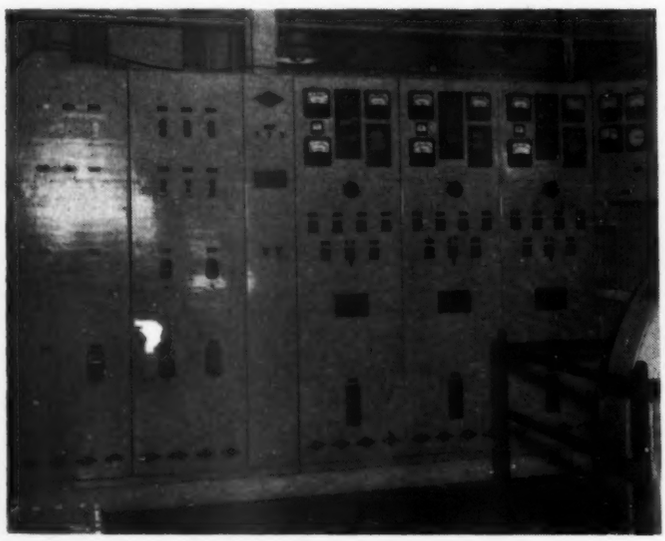


Fin-fan coolers at McComb.

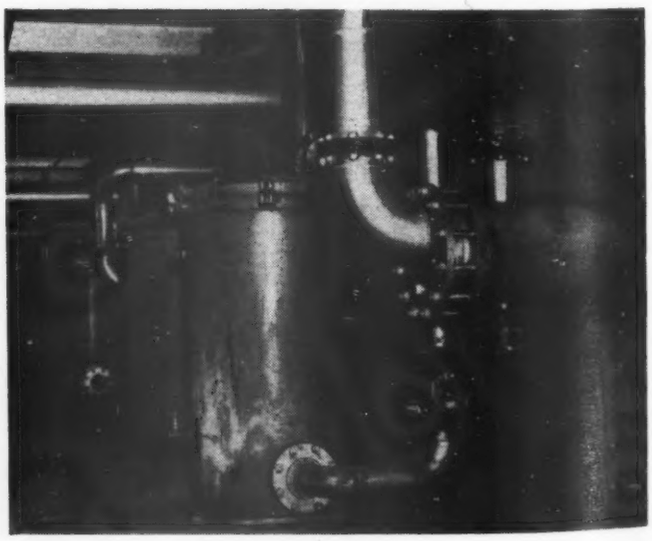
discharge side, the whole passing through a dehydration plant before entering the 24-in. line to Refugio, next station on the system.

At Refugio there are eight 1500-hp compressor units, which, in addition to being connected to the main line from Agua Dulce, are also connected to three inlet lines from low-pressure gas fields. This latter source of supply constitutes a volume of about 135,000,000 cu ft a day. It is compressed, then dehydrated, after which it mixes with the main gas stream from Agua Dulce. Pressure of the latter upon arrival at Refugio is 590 psig. The discharge pressure of the gas is 735 psig.

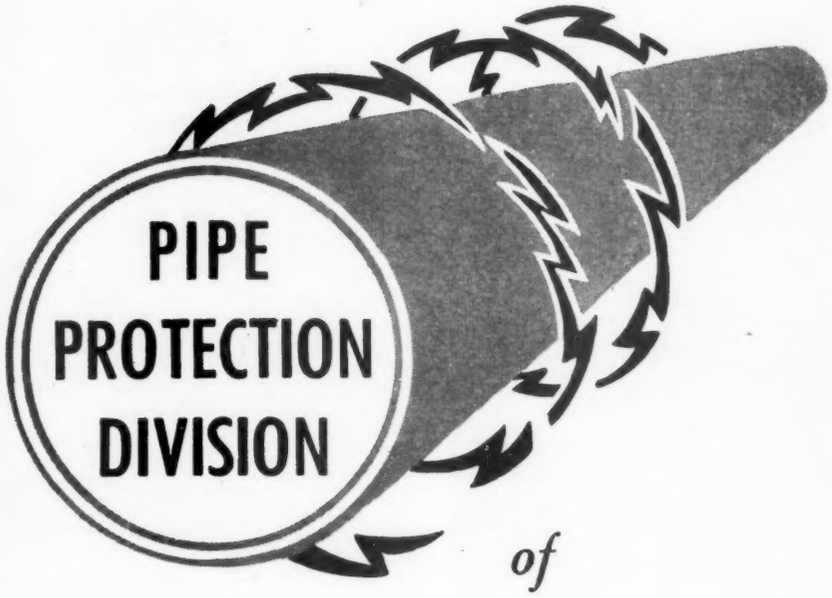
An additional 94,000,000 cu ft of low-pressure gas from the Edna area enters the system at that station, through only one field line. The gas is dehydrated



Control board in auxiliary building, Edna station.



Oil filters.



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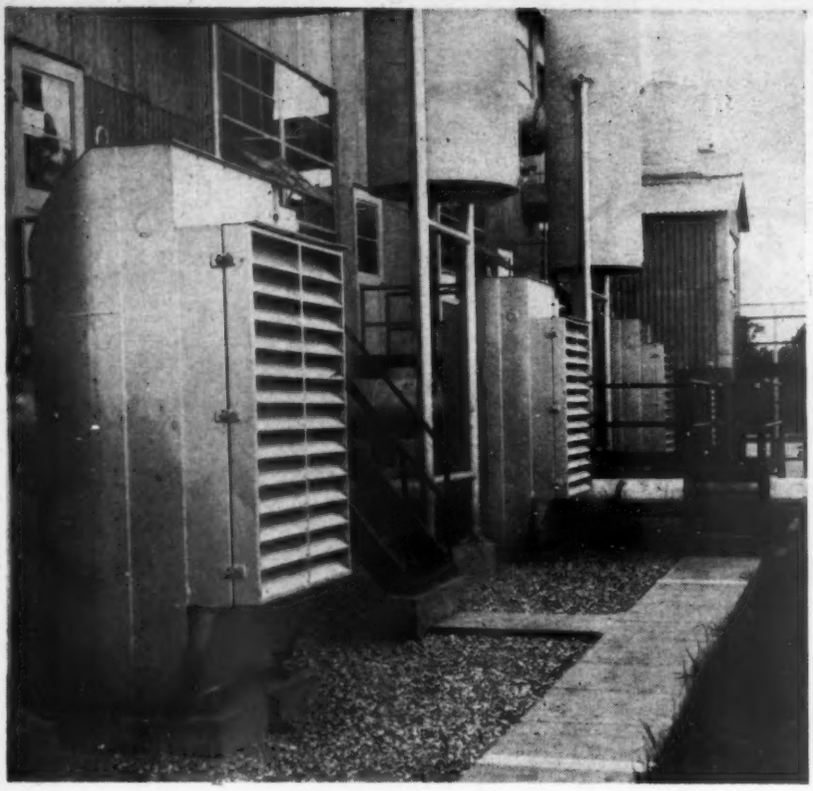


Air filters at McComb compressor station.

Motor-operated valve for starting scraper through line.

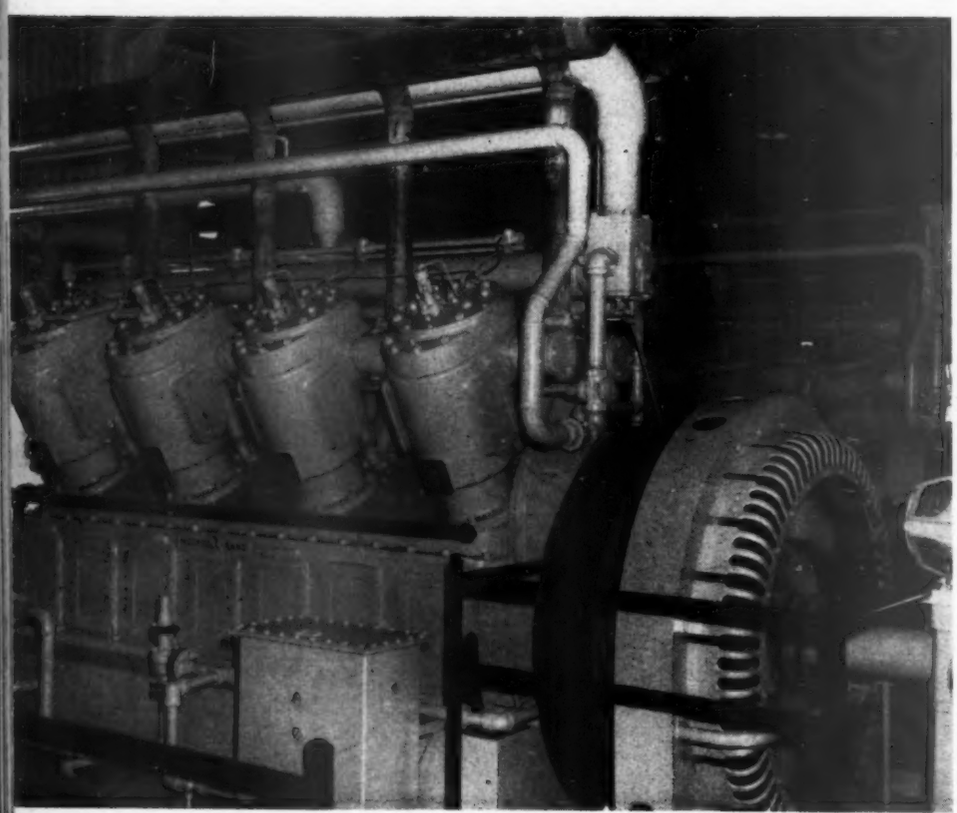
after being compressed. The total volume of gas leaving the station is 416,000,000 cu ft, the discharge pressure being slightly over 800 psig. Suction pressure on the mainline is 660 psig. At Edna, as at Refugio, there are eight 1500-hp compressor units.

Needville, with its six 1320-hp units, is essentially a booster station and takes on no field gas. Gas is received from Edna at a pressure of approximately 660 psig and is boosted to a pressure of 885 psig.

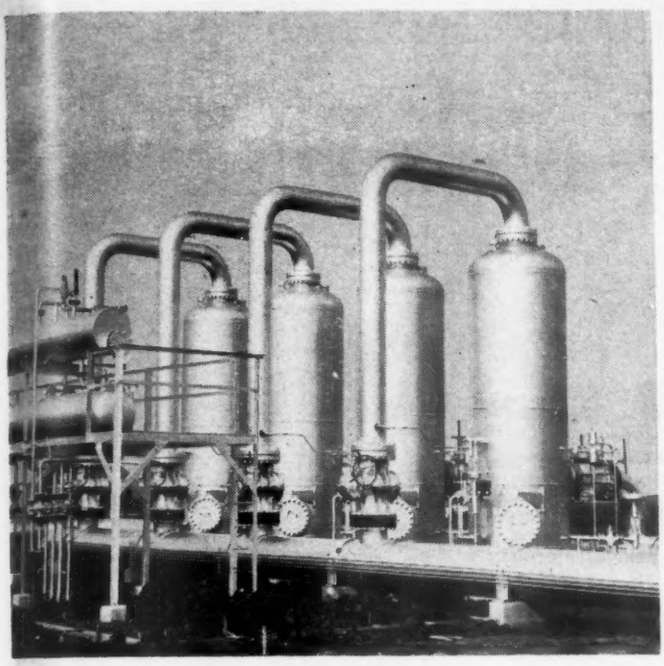
Goodrich also is a booster station, taking gas at a pressure of about 635 psig and discharging at 840 psig. The volume is approximately 395,000,000 cu ft a day. Installed are six 1320-hp units.

Magasco has been enlarged by the addition of two 1000-hp compressor units, thus giving a capacity for pumping 395,000,000 cu ft of gas a day at a discharge pressure of 850 psig. The additions give the station six units, two of which have been valved for compression of low-pressure gas in United's older system. This gas when taken from the older line is not compressed for delivery into the new line as is done in the case of field gas at Refugio and Edna.

The Lafayette station has four 1100-hp compressor units. It is essentially a field station and because of its numerous functions has been designed for maximum flexibility. The station receives low-pressure gas through one or both of two inlet lines, compresses it in two stages, and delivers it through a dehydration plant into a 12-in. line, which connects with the 30-in. line originating offshore. Gas entering the Lafayette station can be taken from the Weeks Island field or from the Franklin-Iowa line. Delivery of gas into the line from offshore will be periodic and when not being used for this purpose the station can deliver into other United lines. The station is manifolded to four lines in a manner that makes it possible for any one or more lines to be an inlet and any

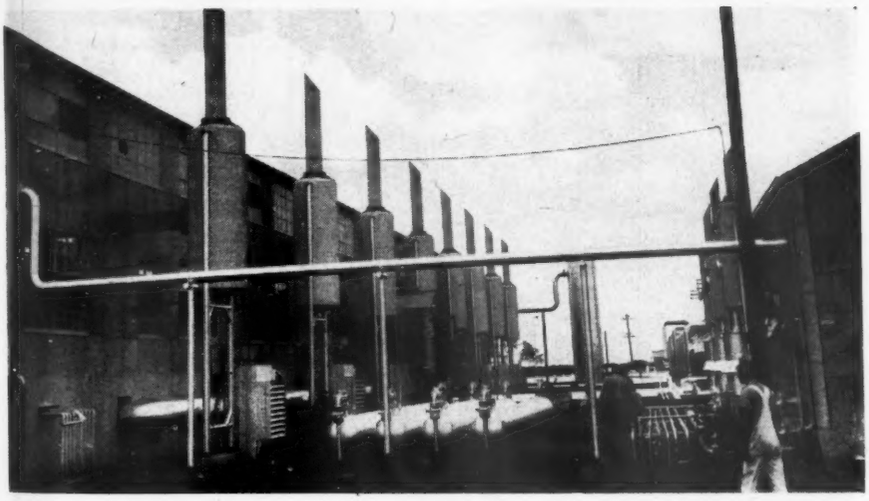


408-bhp gas engine driving 350-kva generator at Edna, Texas, station.



Scrubber installation at Needville station.

Jacket water coolers at Needville, Texas, station.



Above, row of silencers on compressor engines.

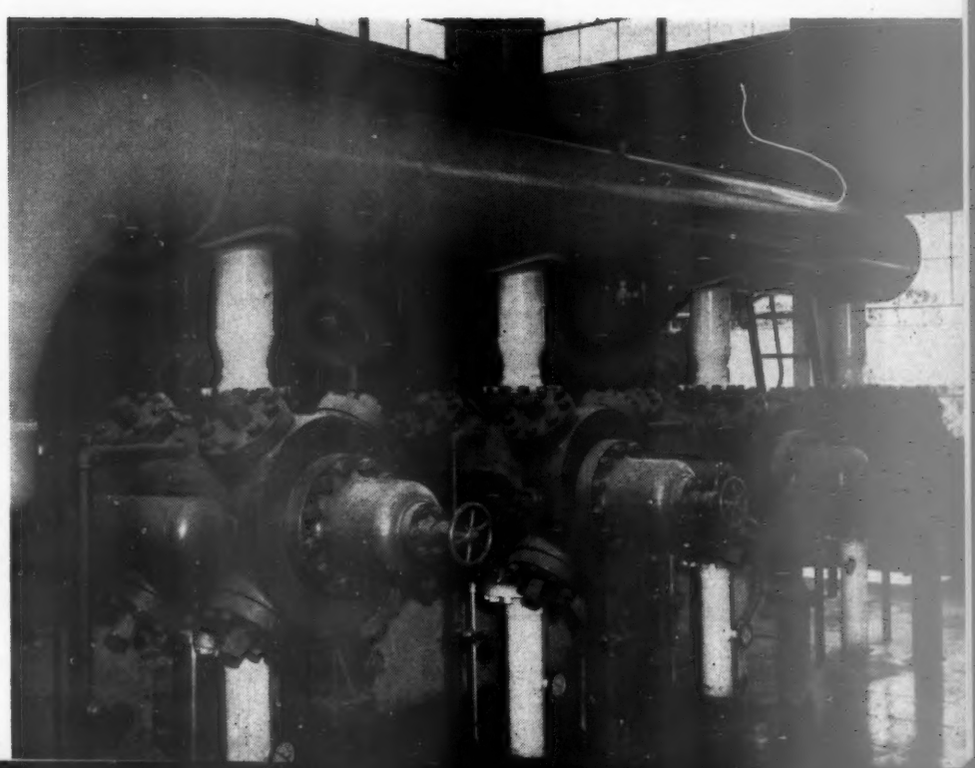
one or more lines to be an outlet. The station can also operate as a single-stage low-pressure station or a single-stage high-pressure station. Further, gas can be bled off between stages or at the discharge line after dehydration.

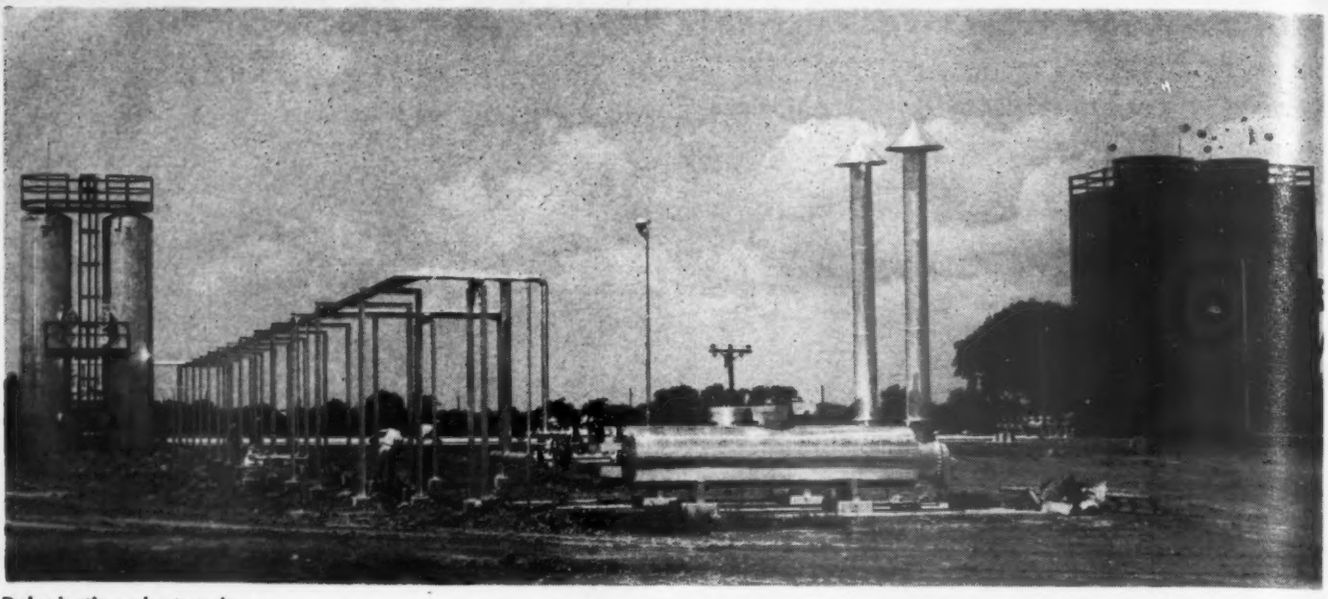
Montpelier station is on a 30-in. mainline and has five 1600-hp compressor units, a total of 8000 hp. There is a single inlet and a single outlet line, gas being received at a pressure of about 720 psig and discharged at 875 psig. Design capacity is for 475,00,000 cu ft a day.

The McComb station, designed to receive 475,000,000 cu ft of gas a day, will pump in two directions. The major part, or about 440,000,000 cu ft a day, is compressed to 900 psig and boosted to Jackson, the remainder being sent southeast toward Mobile, Alabama. From Jackson the gas is delivered to Kosciusko, Mississippi, where approximately 390,000,000 cu ft a day goes to Texas Eastern Transmission Corporation at a pressure of 635 psig. McComb station contains a total of 8000 compressor hp consisting of five 1600-hp units.

Applications are pending before the Federal Power Commission which, if approved, would enable United to increase materially the capacity of the offshore line to Kosciusko by additions to the stations at Montpelier and McComb, and with the construction of new stations near Jackson, Mississippi, and Napoleonville, Louisiana.

1600-hp compressor unit at McComb. Five units of this type were installed in the station.



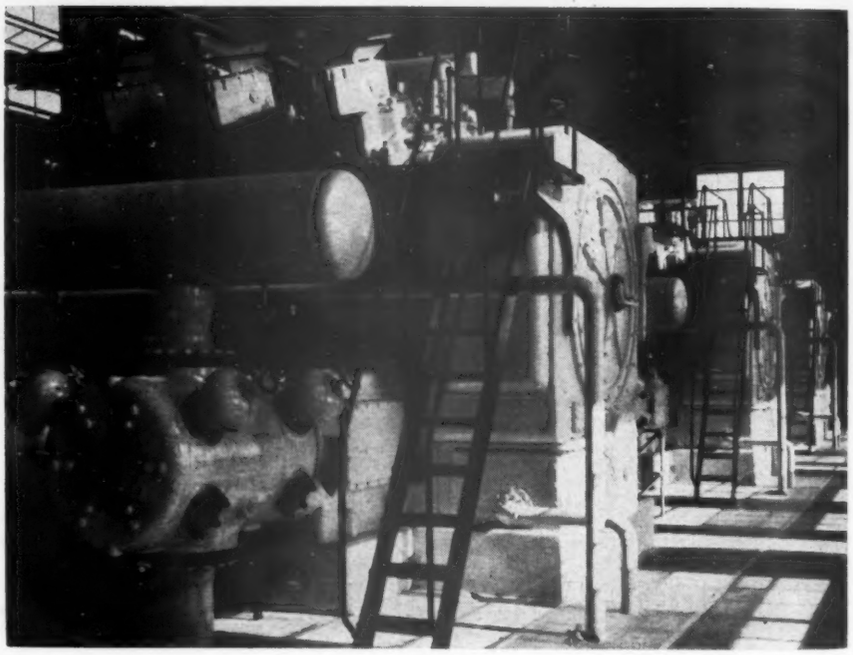


Dehydration plant under construction at Lafayette station.

All compressor units are of the angle type and are driven by 2 or 4-cycle engines. The engines at Magasco, Goodrich, and Needville are driven by 4-cycle engines, and all others by 2-cycle engines. All 2-cycle engines are equipped with automatic engine fuel line venting devices and all engines are equipped with safety devices for overspeed, excessive temperature, and inadequate oil pressure.

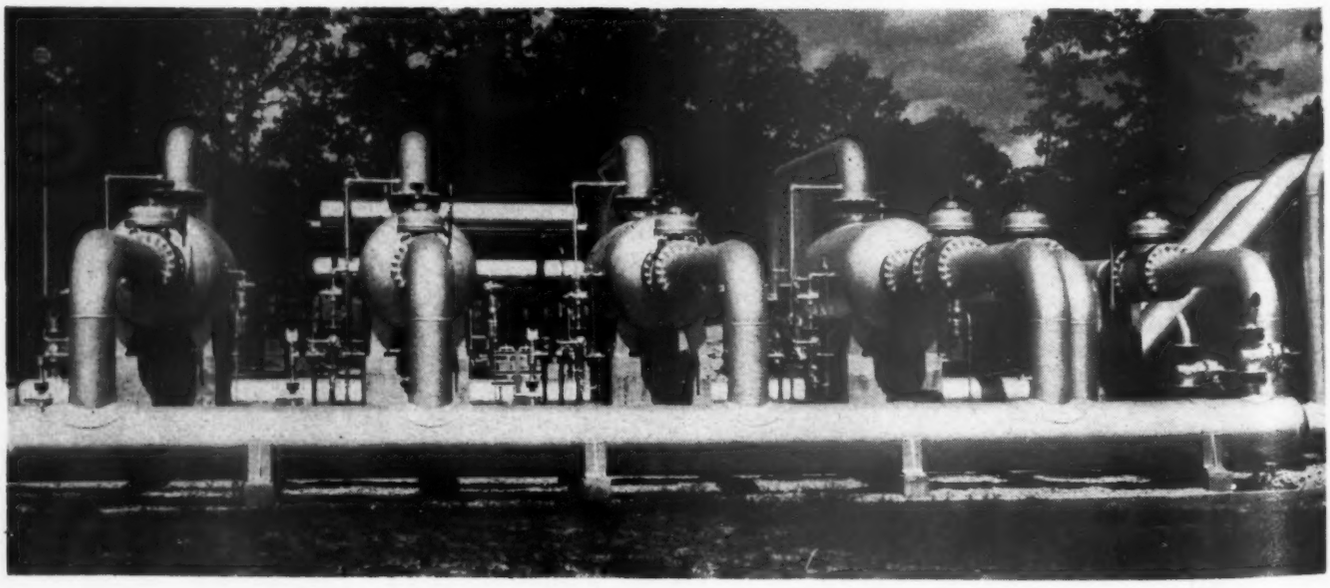
Each compressor unit has been designed to be as nearly self-contained as possible, minimizing the possibility of the entire station going down. Consequently, each unit has its own jacket water pump, and ignition is provided by magnetos on each engine.

Two separate systems supply cooling water to the engines. One system is to the engine jackets, the water being circulated by pumps belt-driven from the compressor engine. The other system



Above, 1500-hp compressor units at Refugio, Texas, station. Eight such units were installed in the station.

Gas scrubbers at McComb.



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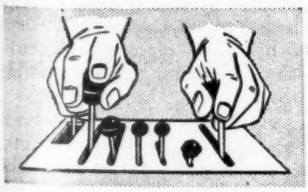

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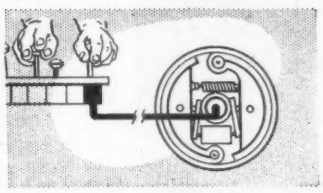

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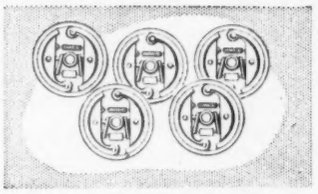

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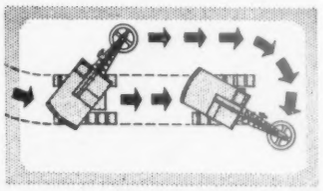

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cools the lubricating oil and compressor cylinder jackets. This latter water is circulated by motor driven pumps. The water in both these systems is cooled by fan-type units.

Gas is cooled only at those stations where it is dehydrated, and the water for this purpose is cooled in induced-draft cooling towers.

The lubricating oil system utilizes both full flow and partial flow filters in each compressor unit. The full flow has a cellulose type filter that removes foreign matter, the oil going to the pressure lubricating system of the engine to cool pistons and bearings. The partial flow system utilizes fuller's earth to prevent excessive acidity and to correct color. This part of the oil is returned directly to the crankcase. The engine lubricator that forces oil to various parts of the engine and compressor uses only new oil. In addition to the abovementioned oil filtering system for each unit, a batch type filtering system is employed to make provision for storing engine oil during maintenance periods and separately filtering this oil during such periods.

Scrubbers have been installed on the inlet side of each station. They are of both the gas cleaner and separator or liquid knockout types, both vertical and horizontal. At stations where field gas is being received, greater emphasis quite naturally is being placed on scrubbers designed to remove liquids, and a cleaner-separator type of scrubber is used. At stations receiving gas only from a previous mainline station the cleaner type scrubber has been installed.

Both purchased power and generated power are used. Where power lines are accessible the power is purchased, and in such instances standby generating equipment is provided for emergencies. At stations where power is generated, multiple 280-kw units have been installed.

Among station features is a non-slam check valve installed just back of the discharge valve on each compressor discharge line. Its function is to hold the discharge pressure off the compressor units until the loading bypass valve is closed, which simplifies the placing of the engine on the line. This check valve makes it possible to start the engine with suction, discharge, and equalizer valves open. Then by slowly closing the equalizer valve the discharge pressure builds up.

On the jacket water system, a check valve is installed on the discharge line, with a bypass around it, so that hot

Top on opposite page, fin-fan coolers at Edna. Engine silencers in background.

Center, relief valves at Goodrich station.

Compressors at Goodrich, Texas station.

water can be backflowed through the engine when down, keeping the engine hot and minimizing condensation.

In the interest of safety, both remote manual controls and automatic shutdown devices are provided. Head gates are equipped with pneumatic valve operators, which are actuated by gas pressure admitted to them by solenoid valves. The solenoid valves are controlled by pushbuttons on the panel board in the auxiliary building. An emergency pushbutton closes the main suction and discharge valves and grounds engine magnetos simultaneously to shut the station down. In case of a rupture in station piping, a differential switch connected to each header does the same thing automatically.

Dehydration Plants

To keep hydrates and water out of the pipe line, 11 dehydration plants have been constructed, their locations and capacities being shown in the accompanying tabulation.

Location	Capacity, cubic feet per day
Baxterville field, Mississippi	100,000,000
Gibson field, Louisiana	110,000,000
Lirette field, Louisiana	100,000,000
Houma field, Louisiana	50,000,000
Lafayette, Louisiana	50,000,000
St. Martinville field, Louisiana	50,000,000
McFaddin field, Texas	110,000,000
Agua Dulce, Texas	220,000,000
Refugio, Texas	150,000,000
Edna, Texas	110,000,000
Greta field, Texas	50,000,000
Total	1,100,000,000

Dehydration plants have been constructed at all points where field gas is handled. Five of these are at compressor stations, and six are in producing gas fields. At stations gas is dehydrated immediately before discharge into the mainline, first having been compressed and cooled. Cooling is in induced-draft type cooling towers, the water being circulated by motor-driven pumps and the fans driven by two-speed motors.

The dehydration plants are of the solid desiccant type. The number of units in each plant varies but each unit consists of two contactors, one being reactivated while the other is on stream. The towers operate on 12-hr cycles and are switched automatically by a time clock.

Better operational control is effected by the design of the contacting towers, which are multiple-bed units with space between beds. This reduces resistance to gas flow with resultant lower pressure drop and prevents channeling of the gas in the desiccant.

The towers are designed for open-shell velocity not to exceed 30 ft per minute, which allows more time for the desiccant to remove the water vapor contained in the gas.

One of the unusual features of these plants is that they are provided with equipment that will measure the volume of water and liquid hydrocarbon removed from the gas for a positive check on the efficiency of the unit. This check is made in addition to a periodic check on water content of the gas made by the U. S. Bureau of Mines dewpoint testing method.

Indirect-fired heaters are used to supply heat to the reactivating gas. The particular heaters employed are unusual in that they have a eutectic salt bed, which operates at atmospheric pressure and approximately 500 F temperature.

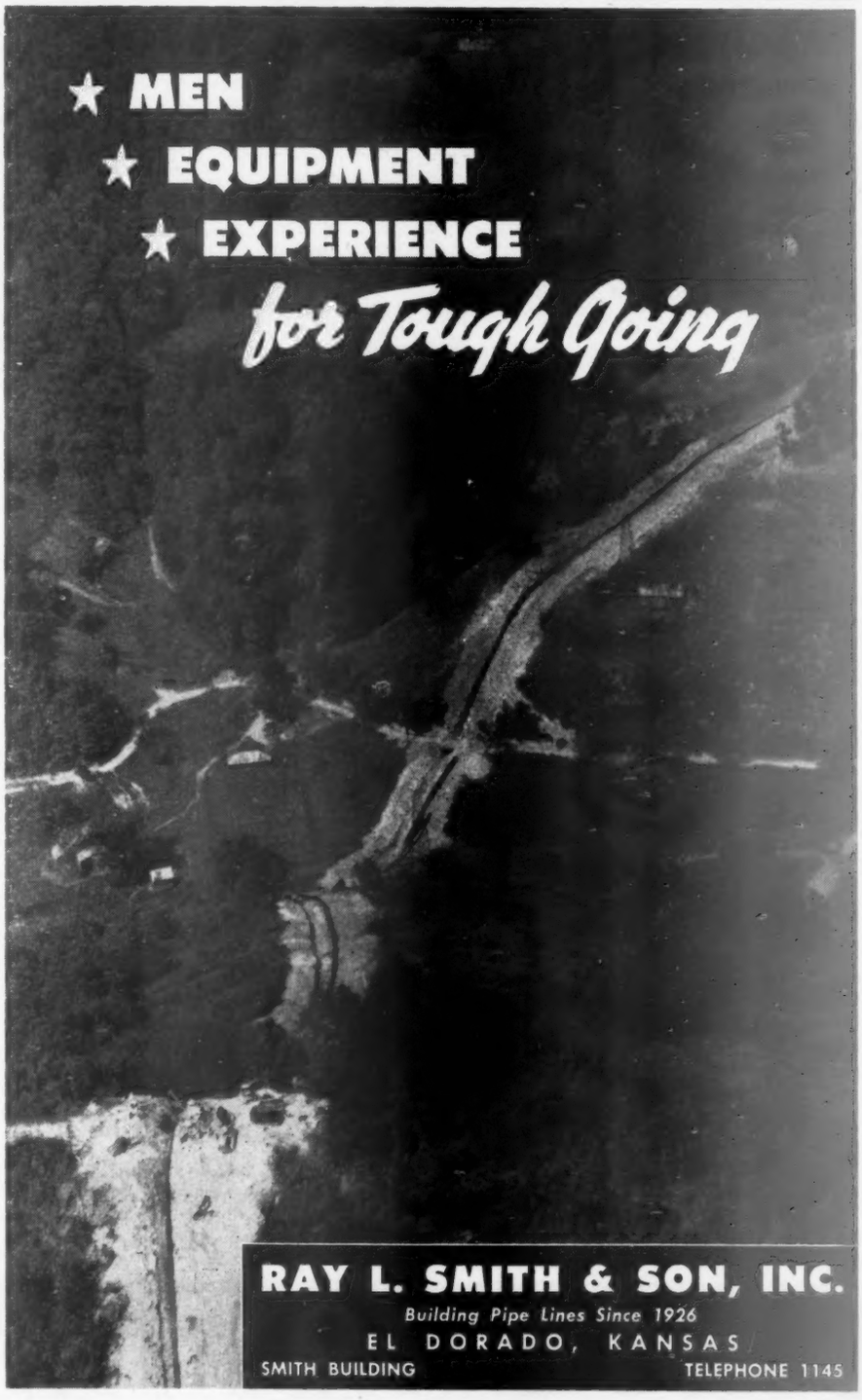
* * *

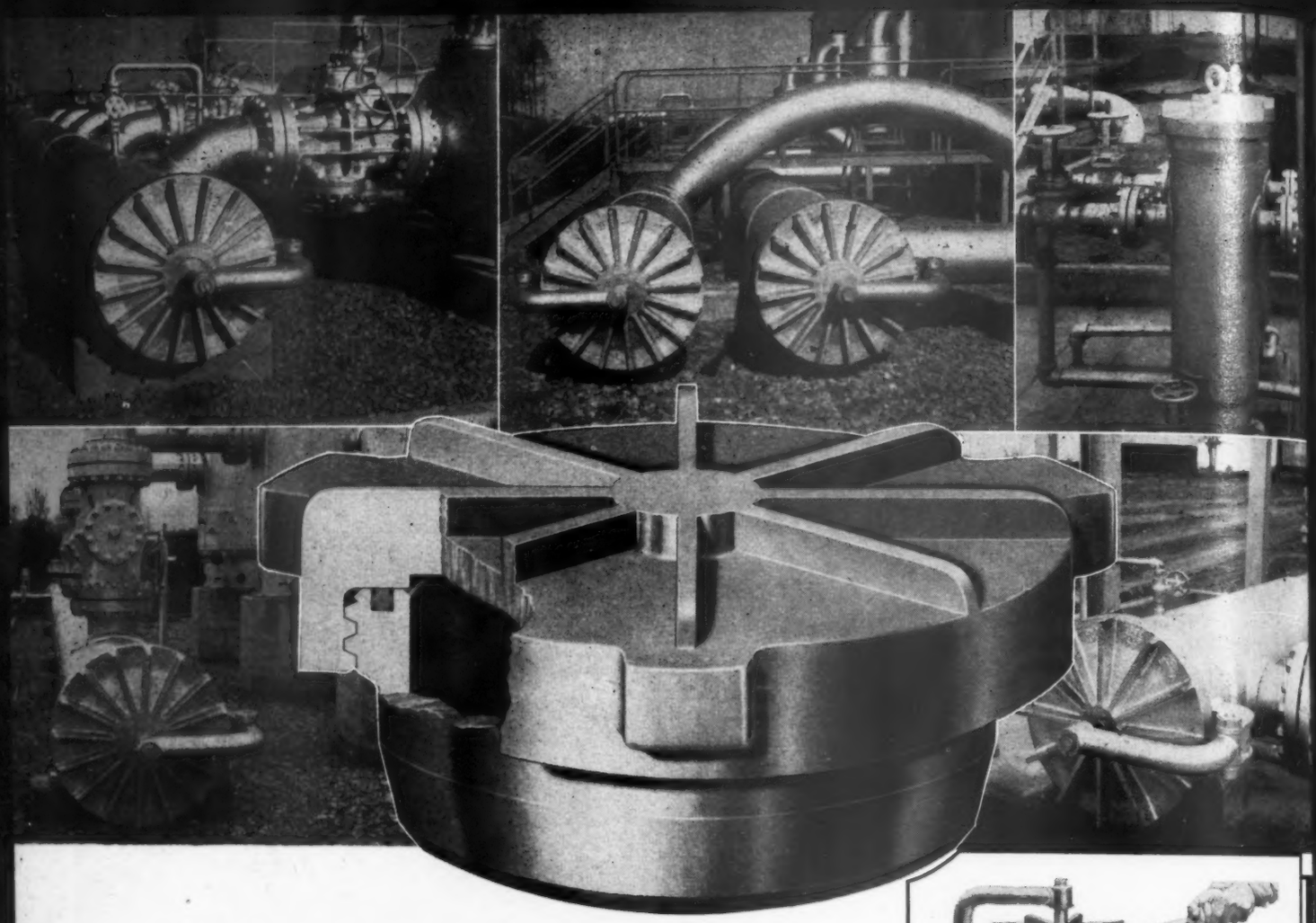
Gas Production Increase

Marketed production of natural gas in the United States climbed to 7,457,359 million cubic feet in 1951 from 6,282,060 million in 1950, according to the U. S. Bureau of Mines. Texas, Louisiana, and New Mexico accounted for 82 per cent of the increase. Production in Pennsylvania after a long static period increased.

The gross quantity of gas placed in underground storage in 1951 was 347,690 million cubic feet, more than a 50 per cent increase over the previous year. The net increase of gas in underground storage during 1951 was 138,262 million cubic feet.

Consumption of natural gas in the United States in 1951 increased to 7,102,562 million cubic feet from 6,026,404 million in 1950. North Carolina, South Carolina, Massachusetts, and New Hampshire received natural gas for the first time. Aside from Texas, California and New York showed the largest increases in consumption.





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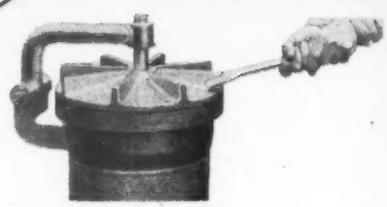

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Trans Mountain—Major Canadian Oil Outlet

Completion of 711-mile line, Edmonton to Vancouver, planned for August, 1953, with initial capacity of 120,000 bbl a day

TRANS MOUNTAIN Oil Pipe Line Company is a Canadian company. It received its Dominion Charter on March 21, 1951, by Special Act of the Parliament of Canada, and was granted on December 13, 1951, a permit by the Board of Transport Commissioners for Canada to construct and operate a crude oil pipe line from the vicinity of Edmonton, Alberta, to the vicinity of Vancouver, British Columbia, by an all-Canadian route.

The pipe line, which will be approximately 711 miles long, will be completed in August, 1953, and oil should reach Vancouver during October, 1953. It not only will serve refineries in the Vancouver area, but also will provide oil for California, the Pacific Northwest, and other offshore markets.

For more than a year prior to the granting of the permit, surveys and studies were carried on by Canadian Bechtel Ltd., a subsidiary of Bechtel Corporation of San Francisco, to determine the best location for the line, the economics of the project, and the total cost.

The data herein concerning Trans Mountain Oil Pipe Line Company, which is currently building a 711-mile, 24-in. pipe line between Edmonton, Alberta, and Vancouver, British Columbia, have been developed to provide basic background information concerning the company, the availability of Alberta crude oil for transport by Trans Mountain, and other related subjects.

Route

Based on these studies, the route (see map) was determined to run westward from Edmonton in the heart of the Alberta oil fields to Jasper National Park, crossing the Yellowhead Pass in the Canadian Rockies at an elevation of approximately 3720 ft. From there, the route crosses into British Columbia, follows the North Thompson River southward to Kamloops, where it turns southwest over a 4000-ft plateau to a point near Merritt. From there, it follows the

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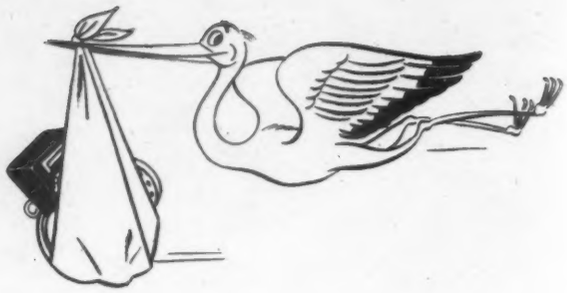

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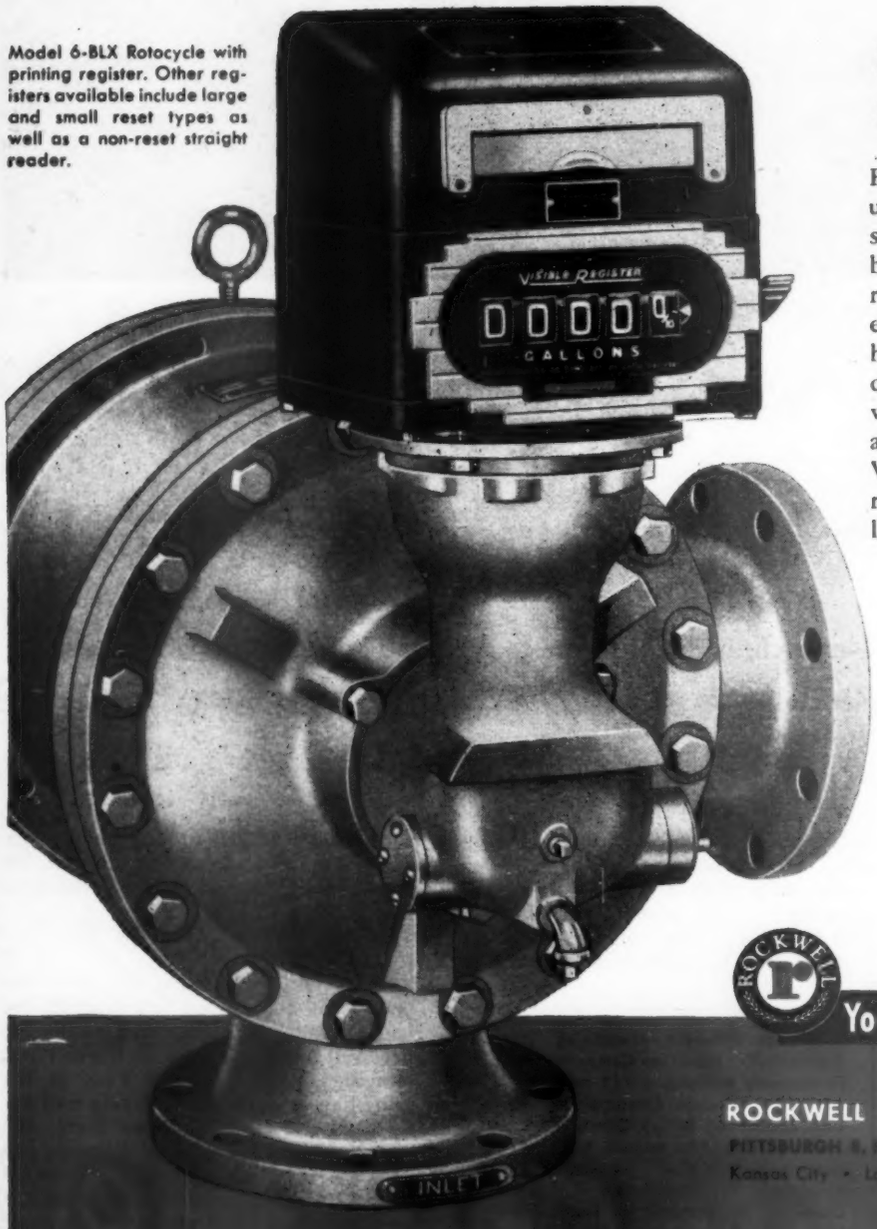

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Capacity 800 GPM Max.

Here is a meter that's "made to measure" for heavy duty, large volume service at loading terminals. Although big in size and output, this free-running meter actually requires less energy to operate than many meters having smaller capacities. That's because of the exclusive Rotocycle "Floward" operating principle in which all working parts smoothly revolve. With it your electric motor and power requirements for pumping will be lessened.

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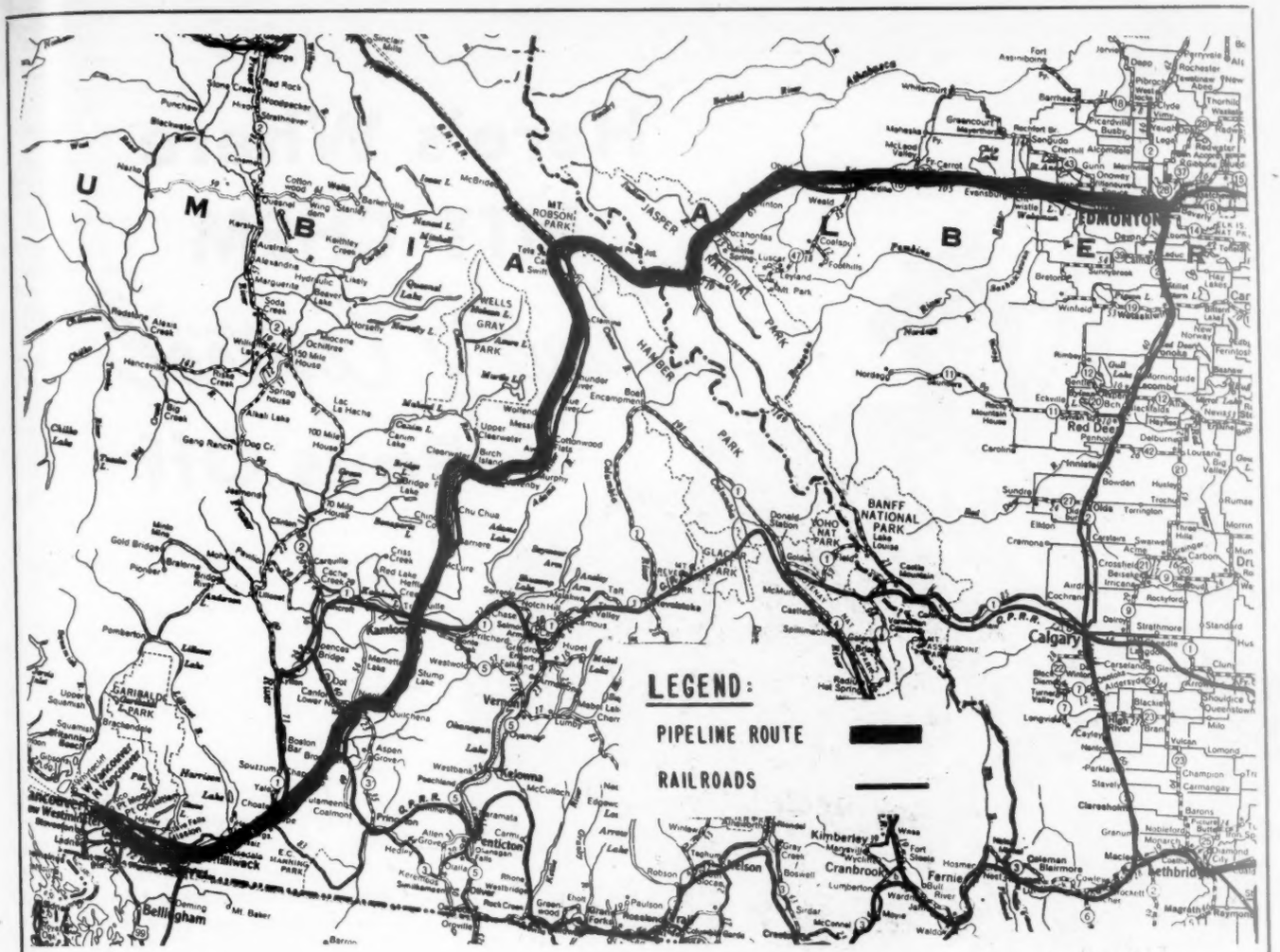

Proposed route for Trans Mountain Oil Pipeline — Canadian Bechtel Limited.

Coldwater River, crosses the Cascade Range at 3700 ft, drops down the Coquihalla Canyon to Hope, and finally swings through the last 90 miles down the Fraser Valley, just north of the International Boundary, to Burnaby, adjacent to Vancouver.

Aerial photographs of the pipe line route gave basic information to land survey parties and saved many manhours during location. Surveys and maps for the line have been provided under contracts by Lockwood, Kessler and Bartlett (Canada) Limited and Phillips, Hamilton, and Associates.

The route has been checked by four consultants: Guy Blanchet, well-known Canadian surveyor; H. H. Hall, retired vice president of Trans Arabian Pipe Line Company; O. W. Peterson, retired chief construction engineer, Pacific Gas and Electric Company, and Dr. R. M. Hardy, dean of engineering, University of Alberta.

Size of Line

Based on field surveys, potential market recoverable reserves and defense requirements, Trans Mountain Oil Pipe Line is constructing a 24-in. diam pipe line to transport crude oil from the Alberta oil fields to the Pacific Coast.

The pipe used is high-test, high-pressure, all-welded steel and varies in thickness from ¼-in. to ½-in. Individual joints range from 32 to 40 ft in length. A 40-ft length weighs about one ton. Approximately 150,000 tons of steel are required for the project. About 5000 railroad cars will be needed to bring the pipe to location.

Although initial construction plans, including two pump stations, were based on a throughput of 75,000 bbl a day, in the light of new discoveries made in Alberta's oil fields and a consequent upward revision of estimates of production, the company's directors in July, 1952, decided to build a third pump station at the outset. Thus, Trans Mountain initially will be able to handle up to 120,000 bbl of crude oil a day, instead of 75,000 bbl as originally scheduled.

The line is designed for an ultimate throughput of in excess of 200,000 bbl a day.

Cost

Initial capital investment for the 24-in. pipe line with a capacity of 120,000 bbl a day has been estimated at approximately $86,000,000. Total investment, with a throughput of in excess of 200,000 bbl a day, based on current costs, will be approximately $97,500,000.

Reserves in Western Canada

Oil reserves in western Canada have been discovered mainly in the Province of Alberta. Large scale development began in 1947 when the Leduc field was discovered southwest of Edmonton.

Recoverable reserves since 1947 have increased from approximately 46,000,000 to in excess of 1,500,000,000, or 33 times, and production potential has increased from 19,000 bbl a day to in excess of 275,000 bbl a day, or 14 times.

A study of the present and future oil reserves in Alberta was made, in October, 1951, on behalf of the company by A. I. Levorsen, in cooperation with Link and Nauss Ltd., consulting geologists, Calgary. A. I. Levorsen is a consulting geologist and former dean of the School of Mineral Sciences at Stanford University in California, and former president of the American Association of Petroleum Geologists and of the Geological Society of America. A summary included in Levorsen's report dated November 8, 1951, indicated:

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"Reserves:
Estimated oil in place, October 1, 1951..3,272,000,000 bbl
Net estimated recoverable oil (less Norman Wells, Peace River area, and Lloydminster area heavy oils), (42 per cent recovery factor).....1,330,000,000 bbl
Estimated recoverable reserves as of December 31, 1953.....1,866,000,000 bbl
Estimated ultimate reserve: Several times the present reserve"

Proved reserves in Alberta, according to the Western Canadian Petroleum Association, have increased as of the middle of June, 1952, from December 31, 1951, from 1,328,000,000 bbl to in excess of 1,487,000,000 bbl, or at an annual rate of in excess of 300,000,000 bbl. Total proved reserves of western Canada during this six-month period increased from approximately 1,376,600,000 bbl to in excess of 1,540,000,000 bbl.

With reference to the rate of production, Levorsen's summary stated:

"It is probable that the maximum efficient rate of annual production (MER) will eventually be around 6 to 8 per cent of the recoverable reserve. An MER of 7 per cent is a reasonable average figure to be used in estimating the amounts of oil available annually."

	6 percent MER, bbl per day	7 percent MER, bbl per day	8 percent MER, bbl per day
MER, Oct. 1951	218,000	255,000	291,000
Est. MER, Summer, 1952[1]	—	275,000[1]	—
Est. MER, 1954	307,000	358,000	409,000
Est. MER, 1955	336,000	390,000	453,000

[1] N. E. Tanner late in June 1952, when he was still Minister of Mines and Minerals, Province of Alberta, stated in Edmonton that at that time potential production of light crude from the Alberta oil fields was in excess of 275,000 bbl a day. He did not indicate the MER involved.

Crude Oil Availability

Assuming a continuation of the 1947-50 rate of discovery of oil in Alberta, an average 42 per cent recovery factor and producibility from recoverable reserves of 7 per cent per year, the estimated availability of Alberta crude oil for transportation by Trans Mountain Oil Pipe Line Company for the years 1952, 1954, and 1955 is shown in the following table compiled by Trans Mountain:

	Barrels per day		
	1952	1954	1955
Producible crude oil supply	275,000[2]	358,000[4]	390,000[4]
Prairie Provinces' requirements	162,000	96,000	100,000
Eastbound pipe line requirements for Great Lakes area (daily average)	162,000[3]	92,000	92,000
Available for Trans Mountain Oil Pipe Line[1]	113,000[1]	170,000[1]	198,000[1]

[1] Assuming that Interprovincial Pipe Line Company and Trans Mountain are the only companies transporting crude oil by pipe line out of Alberta.
[2] Based on statement made by N. E. Tanner, June, 1952.
[3] Prairie Provinces' and eastbound pipe line requirements or Great Lakes area (daily average) combined.
[4] See estimates on rate of production, page 6.

Market

The Pacific Northwest market for crude oil and petroleum products is divided into five major areas, plus a potential offshore market. The five market areas are: Portland, Oregon; Seattle, Washington; Vancouver, British Columbia; Spokane, Washington, and Pasco, Washington. In addition, California and other offshore points may provide additional markets.

Initially, it is anticipated that crude oil delivered through the pipe line will supply the refineries in the Vancouver area and that some additional oil will be exported, possibly to California.

Refining capacity in the Vancouver area in 1950 totaled 29,000 bbl of crude oil a day. There are three refineries in the area, two of which are now being modernized and expanded. Their current capacity, together with their anticipated capacity after their current expansion programs are completed during 1953, is as follows:

	Fall 1952, bbl per day	Fall 1953, bbl per day
Imperial Oil Ltd.	12,000	22,500
Shell Oil Company of Canada, Ltd.	8,000	15,000
Standard Oil Company of British Columbia Ltd.	8,350	8,350
Total capacity	28,350	45,850

Apart from British Columbia, the only refining capacity in the Pacific Northwest area consists of one refinery at Spokane with a daily capacity of approximately 5000 bbl of crude petroleum, and two asphalt plants in Portland and Seattle with a combined daily capacity of 7000 bbl of heavy crude oil.

The following figures, taken from a report dated March 14, 1951, by the Stanford Research Institute, Palo Alto, California, an outstanding non-profit industrial research organization, indicate consumption of refined products in the Pacific Northwest:

Refined products demand and estimated future demand (in terms of barrels of crude oil required per day).

	Vancouver	Seattle	Portland	Spokane	Total
1949...	37,633	87,884	97,640	20,585	243,742
1955...	45,310	108,302	119,851	26,310	299,773
1960...	50,603	121,495	130,416	30,909	333,423

This excludes the Pasco, Washington, area, which is now served by a products pipe line from the Salt Lake area.

In addition to the above markets, there is currently a shortage of crude oil in California. Whether Alberta crude will be used to meet some of this demand in California will depend largely on whether Alberta crude can be laid down in California at competitive prices with crude from other parts of the world.

Tariffs

Trans Mountain Oil Pipe Line Company contemplates making transportation through the pipe line available to shippers generally. On September 8, 1952, the company announced that, based on present estimates of costs and a present indicated initial throughput of approximately 75,000 bbl a day, the initial tariff for transporting oil from Edmonton to Vancouver would be 45 cents per barrel.

The loading charge at the Vancouver marine terminal of the pipe line is expected to be 2½ cents per barrel. It is anticipated that approximately one-half of the initial throughput will be exported by tankers from Vancouver to California, the Pacific Northwest, or other offshore points.

In making this announcement, the company emphasized that the proposed tariff rate was based on present estimated costs and on the quantities of crude oil currently indicated to be transported through the pipe line on its completion.

As the crude oil to be transported through the pipe line materially increases in quantity, the tariff rate per barrel may be lowered.

This tentative tariff was announced at this time to assist western Canadian oil producers in planning for producing oil and marketing it on the Pacific Coast.

Import Duty

During the past year, Canadian crude oil, together with other crude imported into the United States, has been required to pay a duty of 10½ cents on a limited amount of crude and 21 cents on the balance. A new trade agreement recently has been concluded between the United States and Venezuela. This agreement provides that, upon its becoming effective, crude oil with an API rating of 25 deg or above will pay an import duty of 10½ cents, regardless of the quantity imported into the United States.

The reduction of this import duty to 10½ cents, which will apply to Canadian crude as well as Venezuelan oil imported into the United States, will enable Canadian crude transported by Trans Mountain to the Pacific Coast to enter the U. S. market at a reduction in current cost equivalent to the reduction in the import duty. Thus, Alberta crude will be able to compete more directly with California and other crudes in the California and Pacific Northwest markets.

Contracts and Employment

Trans Mountain, as a matter of general policy, is endeavoring to contract as much of the work as possible to Canadian organizations and individuals and to purchase, wherever possible, all necessary materials and supplies from Canadian sources.

Because "Big Inch" pipelining is new in Canada, however, experienced key men from other fields have been brought in. These specialists, in Canada on temporary permits, are working with and training Canadians to carry on the project. As of this fall, approximately 84 per cent of all personnel engaged in the project is Canadian and 16 per cent non-Canadian. The ratio is increasing steadily as Canadians gain experience in "Big Inch" pipelining.

When the pipe line is completed and operating at capacity, permanent employment will be provided for approximately 175 individuals. Trans Mountain's policy, again, is to employ wherever possible Canadian citizens who either are or can be trained in the technicalities of "Big Inch" pipe line operations.

Steel

As no Canadian facilities exist for fabricating the 24-in. diam pipe required, the pipe has been ordered from United States sources—from the Con-

Coat and wrap crew in a swamp east of Yellowhead Pass.

solidated Western Steel Division of United States Steel Company and the Kaiser Steel Corporation, both in the San Francisco, California, Bay area, and from A. O. Smith Corporation in Milwaukee, Wisconsin. The Petroleum Division of the Department of Defense Production in Canada and the Petroleum Administration for Defense in the United States have issued to the company the necessary authority to purchase steel under the Controlled Materials Plan of the United States. These allocations began during the second quarter of 1952 and have continued in an orderly manner.

Construction

Although the route traverses more than 400 miles of mountainous terrain and crosses two main divides, other than at a few critical spots, the route provides a reasonable location for construction and operation of the pipe line.

During the fall of 1951 before the snow fell, Canadian Bechtel Limited, acting as agent for Trans Mountain, took a group of contractors over the route so that bids could be submitted and contracts awarded, thus permitting work to commence early in 1952.

Contracts for the construction of the pipe line initially were awarded to Mannix Ltd. of Calgary for the center section of the pipe line and to Comstock Midwestern Limited of Toronto for most of the eastern and the western end of the pipe line. Later, additional contracts were awarded to Canadian Pipeline Construction Company, Ltd., of Calgary for construction of the line between Edmonton and Acheson, and to Canadian Engineering Surveys, Ltd., of Edmonton for engineering surveys on this latter section of the line.

Before actual construction could begin it was necessary to obtain a 60-ft right-of-way. Clearing of this right-of-way began in February, 1952, and will continue into the spring of 1953.

Those holding contracts for clearing and grubbing various portions of the pipe line's right-of-way include: Campbell Construction Company Ltd. of Calgary; Griffin and Griffin, Ltd., of Cochrane, and Campbell-Bennett, Ltd, of Vancouver.

Contracts will be entered into between Trans Mountain and approximately 3000 landowners — private, municipal, and government—before the clearing is completed. These agreements convey to Trans Mountain the privilege of laying the pipe along the route selected and, in turn, bind Trans Mountain to pay for damages, if any, to crops, fences, and other property of the landowner during construction and maintenance of the pipe line.

Timber on the right-of-way is being valued by registered appraisers and arrangements are being made with individual landowners for the sale or disposal of marketable timber.

Along the route between Edmonton and Vancouver, 140 sidings have been established where the pipe, transported by rail from the fabricating plants, is stacked. From these sidings large specially constructed trucks, operated by Canadian Parkhill Pipe Stringing, Ltd., and Arrow Transfer, Ltd., string the pipe alongside the yard-wide ditch. After the pipe is welded, X-rays are made of a representative number of the welds. If any welds are not up to standard and fail to meet the tests, they are cut out and re-welded. Industrial X-ray, Ltd., of Seattle, Washington, has the contract for X-raying the welds.

Following the welding, rust and scale are removed from the pipe and a protective priming coat is applied. Then a self-propelled machine, known as the coat-and-wrap machine, applies a coal-tar enamel at a temperature of about 475 F, then wraps the pipe with a glass fiber matting and on top of that asbestos felt.

To insure that there are no breaks in the wrapping, a "holiday detector" is passed over the wrapping. If any flaws in the wrapping exist, this device gives an automatic electric signal.

In rock cuts, to protect the pipe further, an extra wrap of asbestos felt, known as "rock shield" is applied.

After this operation is completed, the pipe is lowered into its trench and the earth is replaced by bulldozers and draglines, restoring the earth to its original state and thus permitting farming or other operations to be resumed at once on the surface.

So that the flow of crude oil can be shut off anywhere and at any time if necessary, valves are being installed at distances varying from 10 to 20 miles. These valves stand about 9 ft in height and are welded into the pipe line. They weigh 9000 lb and the total installed cost is about $15,000 per unit.

In order to insure maximum safety, prior to the pipe line's being filled with crude oil and placed in service, the entire line will be tested with air. This operation will add substantially to the overall cost of construction.

Approximately 2,100,000 bbl of crude oil will be required to fill the pipe line. At 1952 fall prices, the value of this oil filling the line will be in excess of $5,000,000.

The pipe line is being buried throughout its entire 711-mile route. In agricultural areas, the pipe is buried so that the top is 30 in. below the surface of the ground. In rocky areas, the top of the pipe will be 24 in. below the surface. Although the line runs through rugged terrain for many miles, less than 5 per cent is in rock. The line will be buried 8 ft or more below the beds of approximately 60 rivers, streams, and creeks that must be crossed. Only 20 of these crossings are considered major jobs.

Construction Schedule

Construction is proceeding according to schedule. As of the end of September, 1952, approximately 200 miles of the 711-mile pipe line had been welded. Welding was proceeding at the rate of approximately three miles per day. By the end of the construction season this fall, between 330 and 400 miles of the pipe line should be welded.

Three pipe laying groups or spreads have been operating this last summer and two additional spreads are operating this fall. As the actual laying of pipe in western Alberta and in most sections of British Columbia is limited to the summer and fall seasons, operations will be curtailed during the winter of 1952-1953.

PIPE LINE PROGRESS

2700 MILES OF LINE PIPE FOR
Tennessee Gas Transmission System

Early in World War II, Tennessee Gas Transmission Company was authorized to construct its 24-inch natural gas pipe line from south Texas to West Virginia. Completed in 1944, this original line helped to supply fuel for the increasing demands of the central East.

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2700 miles of pipe in 16-inch, 20-inch, 24-inch and 26-inch diameters have been shipped by A. O. Smith as its part in supplying Tennessee Gas Transmission's requirements for the original as well as subsequent construction, including looping and extensions that have been completed and are in progress.

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DEPENDABILITY THROUGH RESEARCH AND ENGINEERING

Trans-Mountain pipe line being lowered into trench west of Jasper.

As soon as weather conditions permit in 1953, Trans Mountain will start operating additional spreads and it is anticipated that five to seven pipe line spreads will be operating along the route. The number of spreads during 1953 required in order to have the pipe line completed in August of next year will be determined this winter and will depend on how late this fall weather conditions will permit the spreads now on the line to continue to work economically.

River Crossings

Of the 60 river, stream and creek crossings, the largest and most difficult is that of the Fraser River at Fort Mann, British Columbia. This crossing, consisting of 5700 ft in length (including both shore and water), has been contracted to Missouri Valley Canadian, Ltd., of Winnipeg.

Actual distance across the Fraser is 2250 ft. Twenty-four-inch pipe with walls ½-in. thick will be laid. It will be buried at a minimum of 15 ft below the river bed and will be covered with a continuous 2½-in. concrete casing which will act as ballast to keep the pipe down.

Work on the approaches began this fall, and dredging will be done this winter at low water. The job is scheduled for completion during the winter. The B. C. Bridge and Dredging Company, Ltd., of Vancouver has a sub-contract for excavating and back-filling the trench across the river bed.

Other special river crossings include the North Saskatchewan, which has been contracted to Canadian Pipeline Construction Company, Ltd., of Calgary; the Pembina, McLeod and Athabaska River crossings, which have been contracted to Comstock Midwestern, Ltd., and the North Thompson at Kamloops, which has been contracted to Mannix, Ltd.

Tunneling of two railroad crossings near Rearguard, British Columbia, has been contracted to Wood and McLay, Ltd., of Vancouver.

Terminals and Loading Docks

Two tank farms, or terminals, will be established initially—one at Edmonton and the other at Burnaby near Vancouver.

The tank farm and pumping station at Edmonton, covering an area of 160 acres, is immediately adjacent to the terminal of the Interprovincial Pipe Line. The major Alberta oil fields are now all connected to Edmonton by pipe line gathering systems. By having these two terminals adjacent to each other, facilities will be provided that will permit the transportation of all such oil to markets either in the east or on the West Coast.

Mix Brothers Construction of Edmonton has been awarded a contract for clearing, grubbing, and grading the Edmonton tank farm site.

The western terminal at Burnaby is on a 200-acre tract. In addition, a marine loading facility is being constructed on Vancouver Harbor at Barnet, a few miles from Burnaby.

In connection with the Burnaby tank farm, Breaks Bros. of Whiterock have a contract for clearing the site; Holmes and Wilson Trucking Company, Ltd., of Vancouver for grading, constructing roads, and drainage, and A. I. M. Steel Products Division, Ltd., for fencing the area.

The two terminals at Edmonton and Burnaby initially will have sufficient tank capacity to store in excess of 1,000,000 bbl of crude oil.

At the various pumping stations along the route, there will be additional storage capacity for a limited amount of crude oil.

When Trans Mountain is operating in the neighborhood of 200,000 bbl a day, storage facilities for approximately 5,000,000 bbl will be situated at the two terminals and pump stations along the route.

Cone roof tanks, supplied by Toronto Iron Works, Ltd., are currently being constructed for Marlboro and Edmonton, whereas floating roof tanks, supplied by Horton Steel Works, Ltd., of Toronto, are being constructed for Kamloops and Burnaby.

Pump Stations

In order to handle the initial throughput of 120,000 bbl a day, three pump stations are currently being constructed. Two are in Alberta at Edmonton and Marlboro, and one in British Columbia at Kamloops.

Contracts for the construction of these initial three pump stations, which will cost in excess of $4,000,000, have been let to Mannix Ltd., of Calgary.

Sub-contracts have been awarded to Halse-Martin Construction Company, Ltd., for clearing and grading and to Hume and Rumble, Ltd., of Vancouver for electrical work. Atlas Construction, Ltd., of Kamloops has a contract for grading the Kamloops site.

Power will be provided at Kamloops by the British Columbia Power Commission and at Edmonton by Calgary Power, Ltd.

Erection of the pumping station buildings is scheduled for late this fall so that the engine settings and interior work can be continued through the winter.

Eventually, two additional pump stations and one booster station will be added. Initially, the three pump stations will have 13,200 installed horsepower. Ultimately, the five pump and booster stations will have 33,880 installed horsepower. Vertical 4-cycle diesel engines, manufactured by Nordberg Manufacturing Company at its St. Louis, Missouri, plant, and Bingham Pumps assembled by the Vancouver Iron Works, are being used.

Appointment of Agent

Trans Mountain has entered into an agreement with Canadian Bechtel Limited whereby the latter is acting as agent for Trans Mountain Oil Pipe Line Company and, as such, is responsible for the planning, engineering, supervision, and construction of the line, pump stations, terminals, and other ap-

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purtenances. Canadian Bechtel is a subsidiary of Bechtel Corporation whose headquarters are in San Francisco, California.

Trans Mountain Offices

The head office of Trans Mountain Oil Pipe Line Company is at 314-318 McLeod Building, Edmonton, Alberta. Operating offices are being established in Vancouver, temporarily at 425 Howe Street, Vancouver, B. C.

Effective August 1, 1952, H. H. Anderson, formerly vice president and general manager of Shell Pipe Line Corporation, was appointed vice president and general manager of Trans Mountain Oil Pipe Line Company and has established his headquarters in Vancouver.

Trans Mountain Officers

Officers of Trans Mountain Oil Pipe Line Company are as follows:

S. D. Bechtel, chairman of the board.
R. L. Bridges, president.
H. H. Anderson, vice president and general manager.
S. M. Blair, vice president.
I. G. Wahn, secretary and assistant treasurer.
J. M. Tescher, treasurer and assistant secretary.

Directors of Trans Mountain are as follows:

W. M. V. Ash, president, Shell Oil Company of Canada, Ltd.
R. D. Baker, president, Standard Oil Company of British Columbia, Ltd.
S. D. Bechtel, chairman of the board, Trans Mountain Oil Pipe Line Company, and president, Bechtel Corporation.
R. L. Bridges, president, Trans Mountain Oil Pipe Line Company, and partner, Thelen, Marrin, Johnson, and Bridges.
J. W. Hamilton, director, Imperial Oil Ltd.
J. K. Jamieson, director, Imperial Oil Ltd.
J. G. Spratt, vice president, Anglo-Canadian Oil Company, Ltd.
W. P. Taylor, Union Oil Company of California.
W. J. Wilkins, Gulf Oil Corporation.

Bechtel Personnel

Key personnel for Canadian Bechtel, Ltd., are as follows:

D. L. Roberts, vice president, Canadian Bechtel, Ltd., and project manager for Trans Mountain.
R. L. Hamilton, design consultant.
R. F. Hamilton, engineering manager.
C. E. Barker, construction manager.
J. D. Greveling, lands manager.
W. C. Ralston, administration manager.
J. H. Burroughs, general superintendent.
B. V. Bohne, project engineer.
H. F. Waste, project engineer.
C. L. Crow, superintendent of materials.
A. J. Dalrymple, assistant project manager and public relations officer.

* * *

Instrument Application in Products Pipe Line Industry*

Pumping rates synchronized in closed line system by means of pneumatic controls

HAROLD R. HOYT†

PURPOSE of this paper is to describe in some detail a few of the devices used to control the modern pipe line prime mover. A new method of controlling two related variables, such as pump suction and discharge pressure, is explained. This method utilizes standard pneumatic control equipment with minor modifications. The system permits smooth change over from discharge to suction control or vice versa without overspeeding or surging.

In the early days of the crude oil and products pipe line industry each pumping station pumped into a storage tank at the next downstream station. The pumping units at this station took suction on this so-called surge tank and in turn pumped into a similar tank at the next station.

This procedure was necessary because it was impractical to keep all the pumping units along the line operating at the same rate. Therefore, the surge tank served to accumulate any surplus product or supply any deficiency caused by difference in pumping rates between stations.

This method of operation required additional tankage above that normally required for storage. Evaporation losses and product contamination also resulted from this method of operation.

The obvious cure for these troubles was a satisfactory method of synchronizing pumping rates. If all units on a pipe line could be operated at equal rates, each unit could pump directly into the suction of the next downstream unit and no surge tank would be required. This is known in the industry as closed line pumping or tight line operation.

With the development of the hydraulic governor for internal-combustion engines, much better speed control became possible. Using this new device, several schemes were developed to synchronize the pumping rates of two or more units or stations operating along the same pipe line.

The general method was to utilize the suction or incoming pressure to a pumping unit to vary the governor setting in such a manner that an increase in flow rate and consequently in incoming pressure raised the governor setting. This speeded up the pumping unit, tending to maintain a constant incoming pressure. Vice versa, a drop in suction pressure would lower the governor setting and slow the unit down.

Early Methods of Control

One method utilized a spring loaded piston in a cylinder connected directly to the station incoming line. The piston rod was connected to a rack and pinion mounted on the governor. The pinion was attached to the control knob of the governor. Variations in incoming pressure caused the piston to move in and out against its spring. In so doing, the rack connected to the piston rod turned the pinion attached to the governor control knob, and thus varied the engine speed in the proper direction to maintain approximately a constant incoming pressure to the station.

Another method utilized a metal bellows mounted on top of the governor. (Fig. 1.) The bellows actuated a push rod, which transmitted the bellows movement to the governor speeder spring. Station suction pressure was piped directly to the bellows. Variations in station suction pressure thus changed the governor setting and the speed of the pumping unit.

These methods were usable but far from perfect. Adjustments were difficult and stability poor. Large deviations in throughput required resetting the control to maintain the desired control point.

The Pneumatic Controller

In searching about for better methods and devices for prime mover control, the pneumatic pressure contro'ler was tried and found to be ideally suited for the application at hand.

The pneumatic controller was primarily developed for use in processing plants, oil refineries, chemical plants, etc.

A number of instrument manufacturers make these controllers, all of which operate on the same basic principles.

A majority of the pipe lines operating today use some type of pneumatic controller to control pumping rates. In operation the instrument feeds a controlled air pressure to a diaphragm or bellows mounted on a hydraulic governor similar to that shown in Fig. 1.

In the case of electric powered units, the controller air is fed to a diaphragm-operated throttling valve in the discharge line of the pump.

Operating Principles

The pneumatic recording pressure controller consists of three basic parts: (1) a primary measuring element, usually a bourdon tube; (2) a means of recording pressure readings, usually an

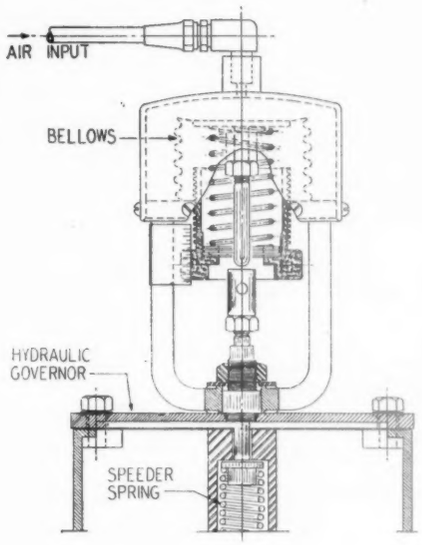


FIG. 1.

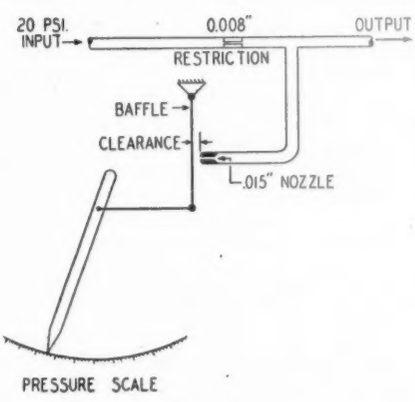


FIG. 2.

*Presented before Petroleum Engineering Conference, American Society of Mechanical Engineers, Kansas City, Missouri, September 22-24, 1952.

†Chief Mechanical Engineer, Great Lakes Pipe Line Company.

TABLE 1.

Nozzle-baffle clearance, in.	Nozzle pressure, psi
0.0000	20.0
0.0005	18.0
0.001	15.5
0.0015	13.0
0.0035	8.0
0.010	4.0

ink pen on a circular chart, and (3) a control unit that converts the measured pressure into a proportionate air pressure, which can be used to actuate cylinders, bellows, diaphragm motors, etc.

The heart of all pneumatic controllers is the nozzle and baffle assembly. Fig. 2 is a schematic diagram of this assembly.

The baffle is positioned on or near the nozzle by means of the bourdon tube and the connecting linkage. The diagram is self-explanatory in that it shows an air supply line, a metering restriction in this line, and a controlled air output line. If the baffle is allowed to rest on the nozzle, very little air can escape, and the output pressure is the same as the input. If the baffle is moved away from the nozzle slightly, more air can escape and the output pressure drops. Table 1 shows the relationship between nozzle baffle clearance and output pressure with a supply pressure of 20 psi.

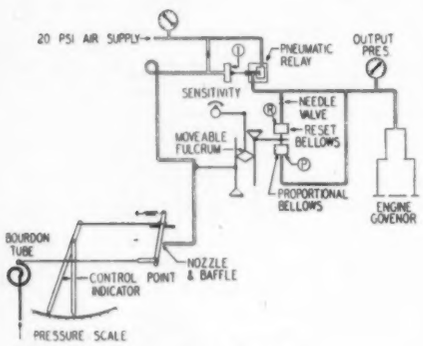


FIG. 3.

Fig. 3 is a schematic diagram of a complete controller showing the nozzle and baffle assembly and all the necessary adjusting devices, relays, and compensating bellows.

If a controller were used that had only a nozzle and baffle assembly as shown in Fig. 2, the air required to actuate the bellows on the governor would all have to pass through the small restriction in the air supply line and the action would be much too slow. To eliminate this trouble, a pneumatic relay with relatively large ports is used as shown in Fig. 3. Variations in nozzle pressure cause diaphragm (1) to move, thus positioning the inner valves in the relay to put more or less pressure on the output air line.

Inspection of Table 1 shows that a very small baffle movement will cause a large change in output pressure. Very small pen movements would cause maximum change in output pressure; without the compensating mechanism consisting of bellows (P) (the proportioning bellows) and its associated linkage. Disregard bellows (R) for the time being.

To describe the action of the proportional bellows, assume that the instrument is in equilibrium, the pen is on the control point and the pen has positioned the baffle at a point such that the air output pressure is 10 psi. Now assume that the measured pressure decreases. The bourdon tube will move the baffle away from the nozzle perhaps as much as ¼ in. This would drop the nozzle pressure to zero and the output pressure to zero if it were not for bellows (P). The output air line is connected to the bellows so that the instant the output starts to drop, bellows (P) contracts and through its linkage moves the nozzle toward the baffle. As soon as the nozzle comes within a few thousandths of an inch of the baffle, the nozzle pressure will start to build up and reposition the pneumatic relay to hold a constant out. pressure somewhat lower than the original 10 psi. The amount the air pressure will drop for a given pen movement depends on the spring rate of bellows (P) and distance it must move to reposition the nozzle against the baffle. The distance it moves is determined by the position of the movable fulcrum. By properly positioning the movable fulcrum, the change in output pressure for a given pen movement can be varied from a fraction of a pound to a full 20 psi. For any specific control application, the fulcrum is adjusted to give as fast a change as possible in controller output without causing hunting and instability. The instrument as described above is said to have adjustable sensitivity.

Consider a pipe line operating with several stations; each pumping unit is equipped with a speed controller as described above. Normally, a suction pressure of approximately 20 psi is maintained at each station. If the initial station either increased or decreased its pumping rate an appreciable amount, each downstream station must increase or decrease its rate the same amount to maintain a constant suction pressure. With the above described instrument, the only way a new speed can be established is for the pen to move above or below the control point. In other words, each downstream station would come to equilibrium with some suction pressure other than 20 psi.

This is the equivalent of speed droop in a non-isochronous governor. To compensate for this undesirable characteristic, an additional bellows (R), called the reset bellows, has been added to the controller. Inspection of Fig. 3 indicates that bellows (R) opposes the proportional bellows (P); however, a needle valve in the air line to bellows (R) retards its action. For any given baffle displacement, the proportional bellows causes the nozzle to follow up the baffle, the pressure in the reset bellows (R) then slowly equalizes with the pressure in bellows (P) through the needle valve. This action gradually draws the nozzle back to its neutral position slowly changing the air output of instrument in the proper direction to bring the measured pressure back to the control point.

A controller with reset action compensates for large load changes and always brings the controlled variable back to the control point. It is the equivalent of an isochronous governor.

In normal pipe line operation, it is desirable to have a controller that will control either suction or discharge pressure if either deviates beyond its safe limits.

Conventional methods of accomplishing this consist of using two controllers in series, one controller measuring discharge pressure and the other suction. The suction controller is direct acting, that is, on an increase in measured pressure the air output increases. The discharge controller is reverse acting. An increase in discharge pressure causes a decrease in air output. The air output of the discharge controller serves as the air supply for the suction controller. The air output of the suction controller is then piped to the speed control unit on the engine governor or the diaphragm operated throttling valve in the case of electric powered centrifugal units.

With this set-up, either control unit can decrease the air to the governor or control valve.

This set-up normally gives acceptable results; however, when the control shifts suddenly from one variable to the other, instability may result with considerable overcontrolling and surging.

An analysis of the system will disclose the reason for this trouble.

Consider two conventional controllers connected in series and each equipped with reset response. Assume that the prime mover speed is being controlled to maintain a pump discharge pressure of 900 psi. Further assume that the suction control point is set at 20 psi and the suction pressure is something above 20 psi. The suction controller will be inoperative at this time. The pressure in the proportional and reset bellows of the suction controller will be equalized, the baffle will be resting against the nozzle and the pneumatic relay will be in a position to deliver maximum air pressure to the governor. If the suction pressure suddenly drops, the suction controller can initiate no correction until the pen has dropped below the control point. As the controller is in a position to deliver maximum output, it requires an appreciable length of time for it to reduce its output to a value that will slow down the pumping unit. During this lag, the controlled pressure will have dropped so far below the control point that the instrument will apply too much correction and considerable cycling or surging may occur before the control again becomes stabilized.

This same condition can exist if the suction pressure is the controlling variable and the discharge pressure suddenly takes over the control.

An Improved Controller

A controller has been devised that eliminates this problem entirely, and at the same time is a simpler and less expensive instrument.

An instrument is used having dual

pressure measuring elements, pens, and control pointer assemblies. Only one pneumatic control unit is used. Its nozzle and baffle assembly may be actuated by either the suction or discharge pen. The second control unit is eliminated entirely and in its place a mechanical link is installed, which makes it possible for the remaining pen also to move the baffle. The result is a pneumatic control unit with a baffle that can be positioned by either the suction pressure pen or the discharge pressure pen.

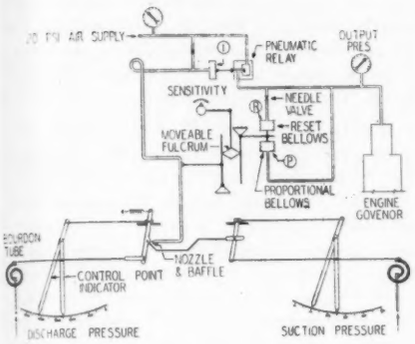


FIG. 4.

Fig. 4 is a schematic drawing of such an instrument. It shows an arrangement whereby the single baffle can be positioned by either pressure measuring element. This drawing is, of course, entirely schematic and bears very little resemblance to any actual instrument. With this scheme the controller is always on the control point. With a change over from discharge to suction control or vice versa there is no lag because there is no shifting from one controller to another. The problem of cycling and surging with possible negative suction pressures is thus eliminated.

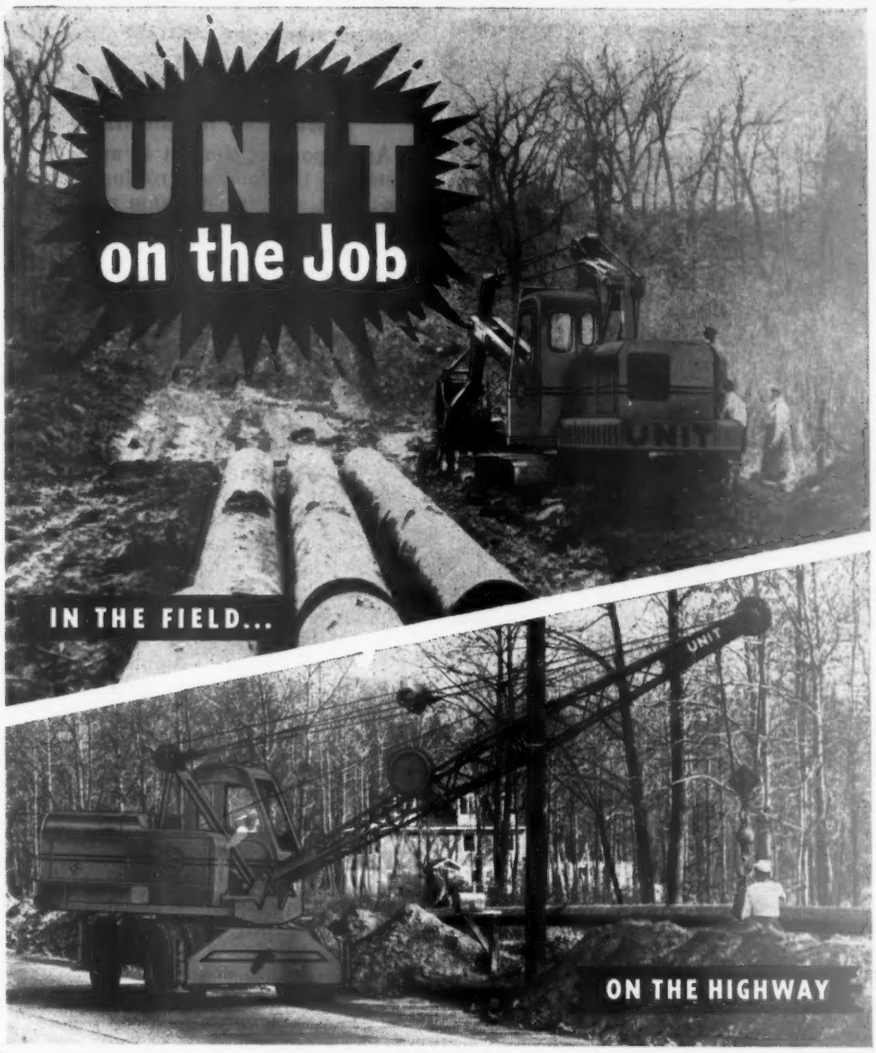
This adaptation has been applied to only one make of instrument to date, but it is possible to modify several of the existing instruments being manufactured today.

Applications

Most of this discussion has described controls for engine-driven centrifugal pumps; however, the same basic control has been applied to electric-powered centrifugal pumps with equal success. In this application the final control element is a diaphragm operated throttling valve on the discharge of the pump. When applied to motor-driven reciprocating pumps, the instrument controls a diaphragm-operated valve in a pump bypass line.

High speed gasoline engines driving centrifugal pumps have been controlled by this type of instrument. In this application a diaphragm motor was used to actuate the carburetor butterfly shaft directly. No governor was used. The engine speed was governed entirely by the pump suction and discharge pressures through the action of the pneumatic controller.

This application has actually proved to have greater stability than installa-



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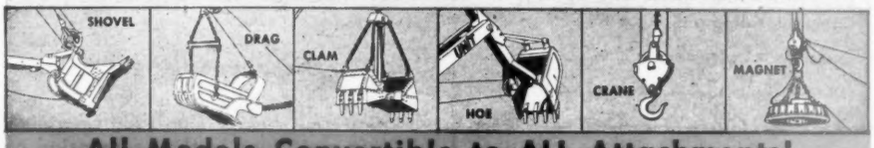

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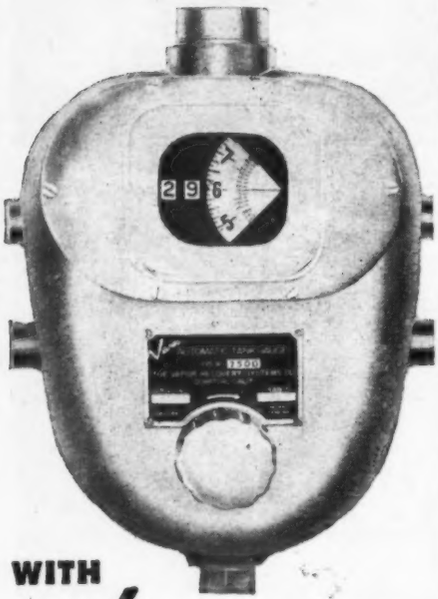

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2-2.

tions in which the controller was used to set a hydraulic governor, which in turn controlled the fuel to the engine.

Positioner Mechanisms

An important element in any control system is the final controlling mechanism; that is the diaphragm motor, bellows, cylinder or other positioning device. In order to attain good results this device must reproduce its position for any given air pressure with a high degree of accuracy. Factors affecting this are the work required of the device and friction or hysteresis in the mechanism itself.

In order to eliminate these effects a device known as a positioner is used. It is in effect a pneumatic servomechanism. The device incorporates a measuring bellows, which receives the air signal from the pneumatic controller. This bellows positions a pilot valve that admits relatively high pressure air to the main diaphragm, cylinder, or bellows that is to be controlled. A follow-up lever is attached to the stem of diaphragm motor or other device. As this stem moves in response to the air supplied by the pilot valve, the connected lever applies an opposing force to the measuring bellows. When the diaphragm stem has moved the proper distance the follow-up lever repositions the bellows and pilot valve in a neutral position and stops the travel of the main diaphragm. Thus a small signal from the pneumatic controller can control a high pressure air source to position a diaphragm or cylinder-operated mechanism or valve. The high pressure air can overcome any existing friction or unbalanced force and eliminate hysteresis.

Positioners are essential on large throttling valves where unbalanced hydraulic forces sometimes exist.

Positioners have been used on the engine speed control system to control precisely the governor setting; however, most positioners have of necessity some rather delicate parts. When subjected to engine vibration these devices lose some of their accuracy and are rather short lived.

It is the writer's opinion that a well designed diaphragm or bellows unit with special care being taken to eliminate friction gives the best over all results.

Conclusion

Pneumatic controls offer a highly satisfactory method of controlling pipe line prime movers. By utilizing these control systems, it becomes possible to operate a closed line system and synchronize pumping rates automatically at all stations regardless of changes in throughput or density of product.

The modified controller described in this paper overcomes one of the problems inherent in conventional controllers.

Acknowledgment

The author wishes to thank J. R. Giese of the Great Lakes Pipe Line Company for his assistance in the preparation of this paper.

* * *

DPA Grants Tax Write-Off On Pipe Line Facilities

The U. S. Pipe Line Company of New York City has been granted a certificate of necessity authorizing it speeded up amortization on a total of $139,781,000 worth of new petroleum pipe line facilities by the Defense Production Administration.

This certificate will allow U. S. Pipe Line to write off, for income tax purposes, 25 per cent of $137,171,000 and 40 per cent of $2,610,000 over a 5-year period instead of the longer period normally required by the government for depreciation of such facilities. The certificate replaces an old one granted U. S. Pipe Line last April.

Early in October U. S. Pipe Line began work on a pipe line to transport all types of refined petroleum products, including liquefied petroleum gases and natural gasoline from Port Neches, will serve Shreveport, Louisiana, Jackson, Mississippi, Memphis and Nashville, Tennessee, Lexington, Kentucky, Cincinnati, Dayton, and Columbus, Ohio, Pittsburgh and Harrisburg, Pennsylvania. Feeder lines are also planned from Texas City, Beaumont, Houston, and Port Arthur, Texas, and Lake Charles, as well as a lateral delivery line from Jackson to Paducah, Kentucky.

The company will also build facilities necessary to support its main transmission line, and plans to complete the project about September 1, 1953.

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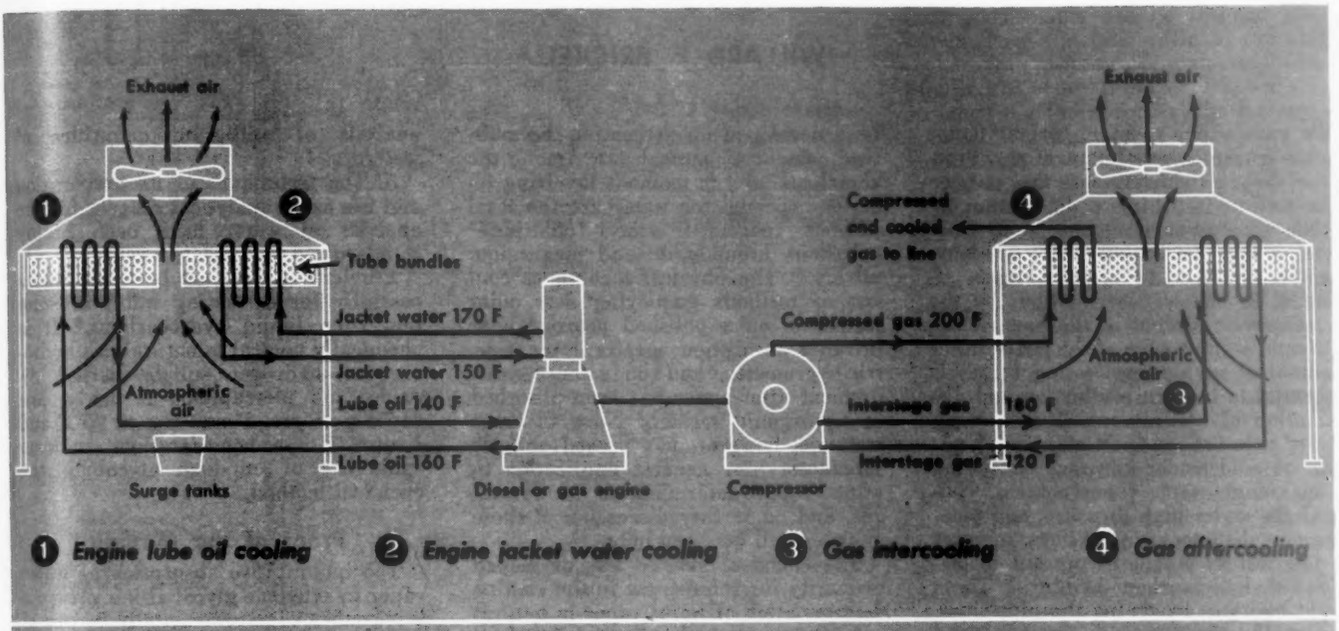

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Determination of Water Vapor in Natural Gas by Direct Chemical Method†

WILLARD F. BRICKELL*

WATER vapor is an important factor in the transmission of natural gas. Processes through which the gas may pass on the way to its ultimate destination include transmission, compression, catalytic conversion, extraction, and dehydration. Each of these processes is affected, in one way or another, by the water vapor content of the gas. Consequently, a knowledge of the water vapor content at various processing stages is essential to modern production and distribution of natural gas. This is especially true for the bulk of finished gas that is sold under contract specifying a maximum water vapor content. Natural gas under high pressure, and passing long distances in pipe lines, requires a low water content to prevent formation of hydrocarbon hydrates. These solid hydrates may plug the pipe lines, especially during cold weather, and cause disruption of services during the periods of greatest demand.

As control of the water vapor content of natural gas is dependent on the method by which it is determined, it is desirable to have a method that functions equally well for varying gas compositions. Separate analyses and corrections for interfering components exhibit, within themselves, sources of error that are to be avoided if at all possible.

The Bureau of Mines Dew-Point Test, described by Deaton and Frost,[3] has fulfilled most of the requirements for such a method since its development in 1938, and because of this, it is considered the standard method for determination of water vapor in natural gas. Its application is limited, however, to gas whose dew-point temperature is not lower than the temperature at which other component vapors condense.[2] In addition, it has been pointed out[14] that the method is not applicable for a gas that contains vapors of glycols or glycol-amines.

With the steady increase in number of glycol and glycol-amine type dehydration systems appearing throughout the natural gas industry and because of the mounting demands for gas of specified water content, it has become increasingly important to have a basic reference method that is suitable for general application to the determination of water vapor in natural gas.

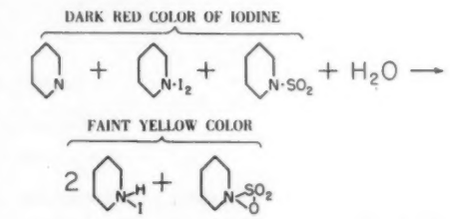
Numerous methods, involving both chemical and physical techniques, have been developed for estimating the moisture content of natural gas. Among the chemicals used in methods involving reactions specific for water are the Karl Fischer reagent,[17] acetyl chloride,[16] cobaltous bromide,[1,10] and magnesium nitride.[15] The physical techniques consist of methods employing dew point formation on a polished mirror,[3] near infrared absorption spectra,[19] the electric hygrometer,[4] and conductance measurement after water has been absorbed in an organic solvent.[8] None of these methods, however, has proved entirely satisfactory for general application to water vapor determination in natural gas, and no further discussion of these methods will be given here.

The chemical method was developed primarily for referee use in the routine determination of water vapor in natural gas. It employs the use of ethylene glycol for extracting water vapor from natural gas at high pressure followed by titration of the water absorbed with Karl Fischer reagent.

Theoretical Considerations

Karl Fischer reagent is a methanol solution of iodine, pyridine, and sulfur dioxide. It reacts mole per mole with water according to the following main equation:[17]

Main reaction equation for Karl Fischer reagent with water.



Numerous side reactions occur both in the preparation of the reagent and upon reaction of the reagent with water. The reaction products do not affect, in any way, the function of the above reaction, which alone involves chemical reaction with water.

The choice of Karl Fischer reagent for use in the analysis of water in ethylene glycol was based on the following considerations:

1. It is completely miscible with ethylene glycol.
2. It is chemically neutral to ethylene glycol.
3. Its reaction with water is specific.
4. It provides high accuracy in the analysis of milligram quantities of water.
5. The techniques of its preparation and use as an analytical reagent for the analysis of water have been highly standardized and widely used.[17]

Ethylene glycol has been used successfully for extracting water of solution from liquid hydrocarbons.[5] It is chemically neutral to natural gas hydrocarbons, hydrogen sulfide, carbon dioxide, and mercaptans. It has a low vapor pressure, 1 mm. Hg. at 95 F and 1 atm. These considerations indicate suitability of ethylene glycol to the chemical method.

Proof of the Method

The quantitative absorption of water vapor by ethylene glycol at low pressure was confirmed experimentally by use of the relative humidities of saturated salt solutions and distilled water, the values of which showed good agreement with other investigators.[7,12,18]

Table 1 shows a comparison of the experimental data with published data for the corresponding relative humidities of two salt solutions and of distilled water. The maximum disagreement was less than 6 per cent and the average disagreement was less than 4 per cent. The experimental data for saturated salt solutions, having a hydrostatic pressure

TABLE 1. Relative humidity of saturated salt solutions — experimental data versus data.

Published in the International Critical Tables

Temp., °C ± 0.5 Saturated Salt Solution	% R. H. (experimental) 850 mm. Hg.	% R. H. (I.C.T.) 760 mm. Hg.
Lithium Chloride Monohydrate		
37.6	10.25	10.72
37.6	10.43	10.72
45.0	10.12	10.48
45.0	10.49	10.48
54.2	10.52	10.30
Magnesium Chloride Hexahydrate		
37.6	30.28	31.83
37.7	30.01	31.73
37.8	30.43	31.63
Distilled Water		
Temp., °C ± 0.5 H_2O	% R. H. (experimental) 800 mm. Hg.	% R. H. (theoretical) 760 mm. Hg.
15.0	105.6	100.0
11.0	97.2	100.0
14.5	104.0	100.0
11.5	105.7	100.0
15.0	104.2	100.0

†Presented before, Operating Section, American Gas Association, May, 1952

*Research Department, United Gas Corporation, Shreveport, La.

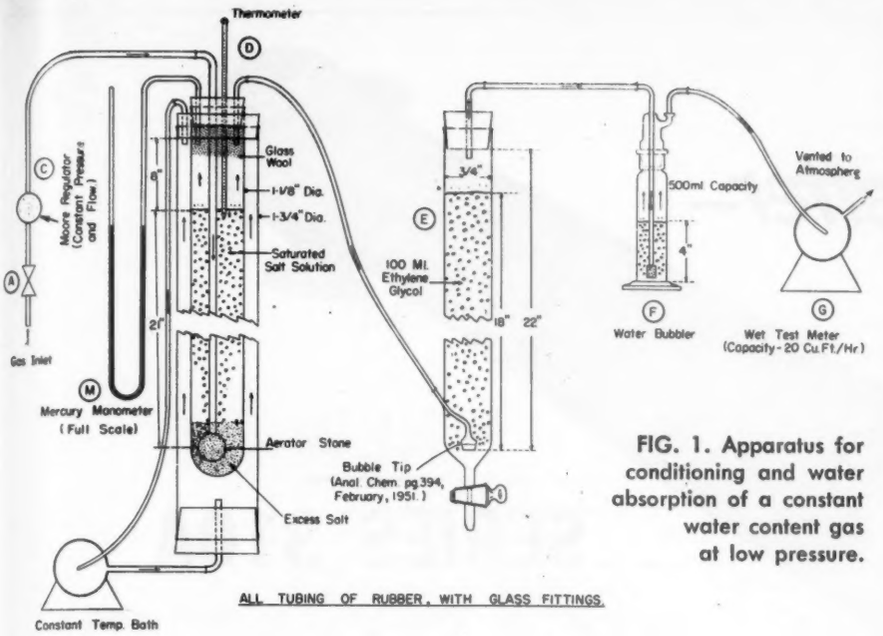


FIG. 1. Apparatus for conditioning and water absorption of a constant water content gas at low pressure.

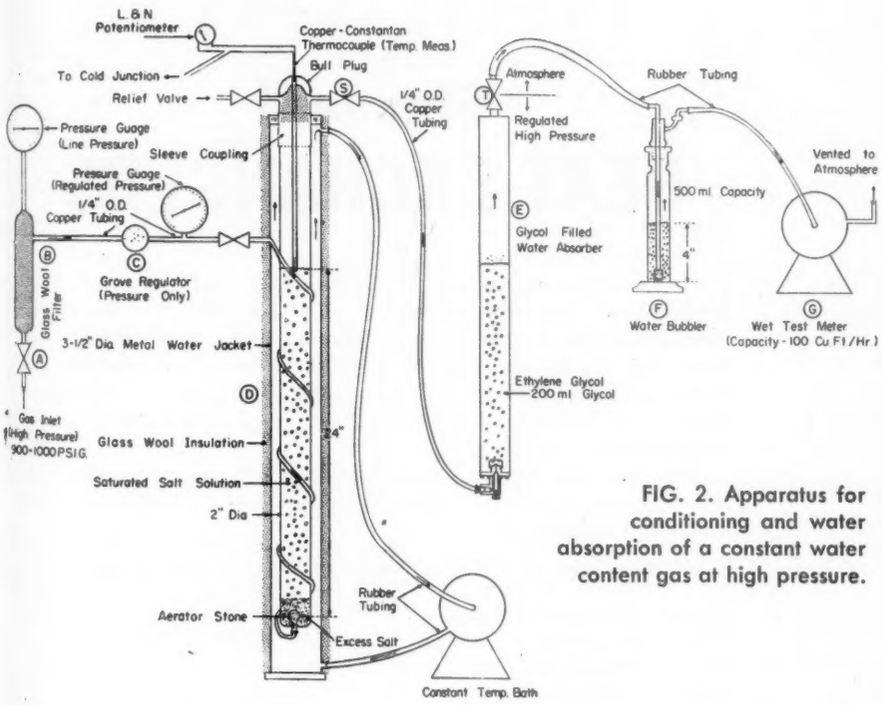


FIG. 2. Apparatus for conditioning and water absorption of a constant water content gas at high pressure.

of 90 millimeters of mercury, is in general agreement with Gokcen's recent investigation,[6] which showed that elimination of the hydrostatic pressure increased the relative humidity by about two per cent.

Fig. 1 shows a schematic diagram of the apparatus used in these test. Air entering at valve, A, at the rate of 2.0 cu ft per hour, passed through a Moore regulator, C, and entered the bottom of the water vapor conditioner, D, through a sphere-shaped aerator stone. This aerator stone provided small gas bubbles, which were much desired for efficient liquid-gas contact. The conditioner contained a saturated salt solution with enough excess crystals to maintain a saturated solution throughout the tests. A glass wool plug provided a mist extractor above the solution to prevent entrained liquid from contaminating the water absorber, E. The exit gas from the absorber was saturated at the water bubbler, F, and was metered by the wet test meter, G. Constant temperature of the saturated salt solution, and the contacting gas, was controlled to within ± 0.5 F by use of a circulating type constant temperature bath connected to a glass wool insulated water jacket enclosing the saturator. After completion of each test, a comparison was made of the amount of water vapor absorbed by the glycol with the calculated theoretical amount in the volume of gas metered.

The apparatus for determination of water vapor conditioned by saturated magnesium chloride at high pressure is shown in Fig. 2. This apparatus is essentially a duplication of the design shown in Fig. 1 with appropriate changes to high pressure materials. A glass wool filter, B, was installed near the gas inlet to remove dust. The low pressure regulator was replaced by a Grove Model 94 high pressure regulator, C, for reducing line pressure of 1000 psia to the desired operating pressure, 850 psia. This was done to aid in stabilizing the operating pressure. The water absorber, E, (detailed in Fig. 3) was developed as a possible working model; but as it proved to be satisfactory, no other designs were tested. A point that deserves special consideration is the fact that glycol must not be trapped upstream from the inlet valve of the absorber. One drop, or approximately five hundredths of a millimeter, located upstream from the absorber interior may contain 30 milligrams of water when at equilibrium with a water saturated gas at 100 F and 1000 psia, thus affecting the final result by as much as 25 per cent. To prevent this condition, the absorber was kept inverted and the inlet valve closed until the actual test was begun. Once the inlet valve was opened, it was not closed again until the absorption was completed. No difficulty was encountered, as indicated by the final results, when these precautions were taken.

In operating this apparatus, the system was purged through valve S for 12 hr before starting a run. This was done at test pressure with a flow rate of approximately 5 std cu ft per hour. Temperature of the saturated salt solution and the contacting gas was maintained constantly near 86 F throughout the tests. Temperature measurements at the solution surface were made prior to, and during, each run by means of a copper-constantan thermocouple and a Leeds and Northrup type K2 potentiometer to an accuracy of ± 0.1 F.

Table 2 shows data obtained for water vapor in equilibrium with saturated magnesium chloride at high pressure. The value of 15.3 ± 1.0 lb H_2O per 1,000,000 cu ft represents the precision of the data. In practical application of the method, where only water vapor absorption is involved, a higher precision could be expected. Comparison of the experimental data for the saturation value of water vapor in nitrogen at high pressure, with extrapolated values of results obtained in an investigation by McKetta and Katz,[9] is shown in Table 3.

These data give a strong indication

TABLE 2. Water vapor content of natural gas in equilibrium with saturated magnesium chloride at 850 psia and a gas flow rate of 2 cu ft per hour.

Temp., F $\pm$ 0.1 Mg Cl_2 0.6 H_2O	Lb H_2O/MM cu ft @ 60 F and 14.7 psia
86.0	15.3
86.0	16.2
85.7	16.2
86.0	15.1
85.4	15.3
86.0	15.6
85.8	15.8
85.5	14.3
85.8	14.6
85.4	15.3
86.0	15.0
Average	15.3
Max. Deviation	$\pm$ 1.0
Std. Deviation	0.6

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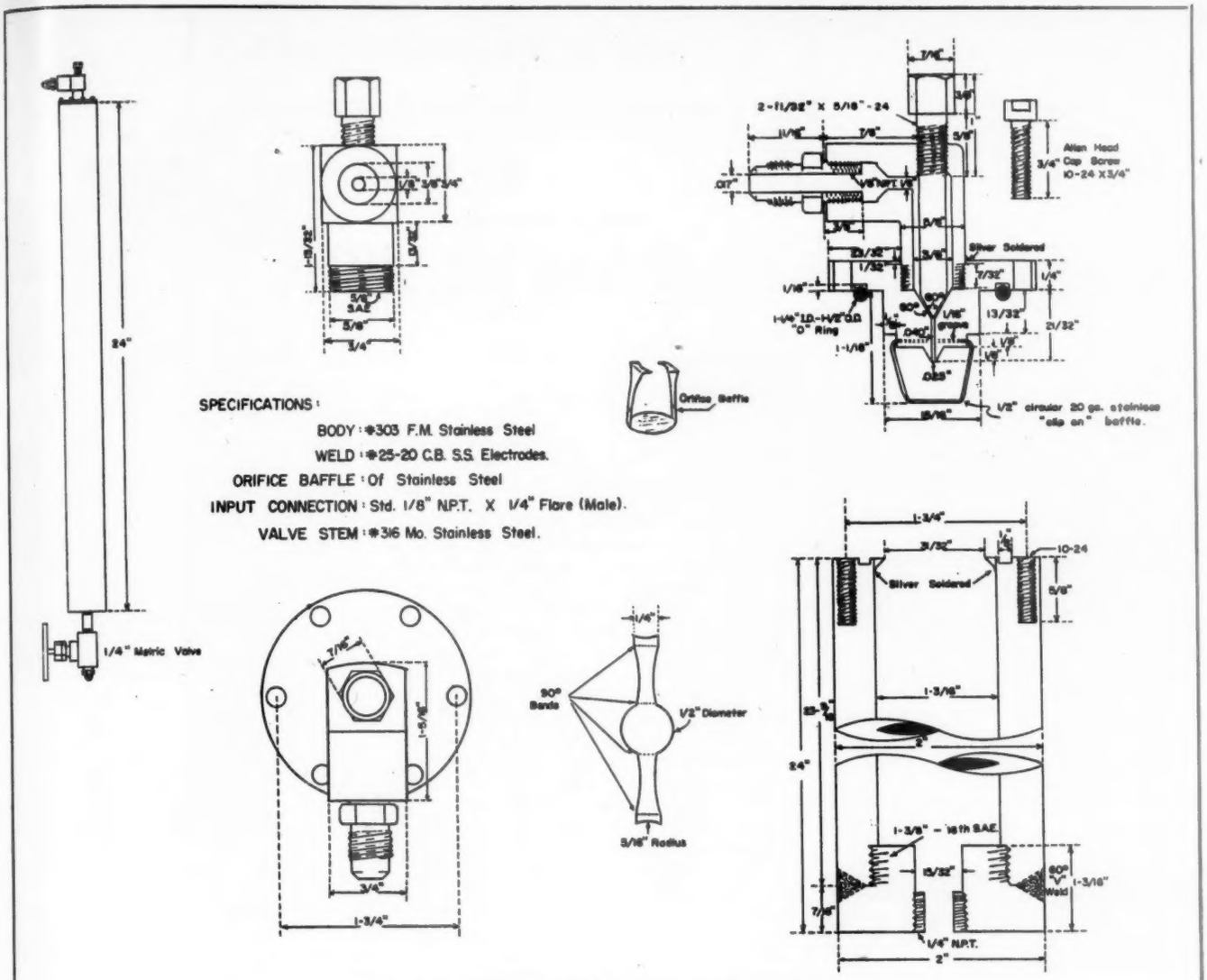

FIG. 3. Absorber for water vapor at high pressure.

that absorption of water vapor by ethylene glycol is essentially quantitative for all ranges of water vapor concentration.

Interferences

The interfering substances considered here are hydrogen sulfide and mercaptans. It is known that most organic sulfur compounds including carbon disulfide, sulfur dioxide, thiophene, and alkyl sulfides are inert to the Karl Fischer reagent.[17] Glycol and glycol-amine vapors from dehydration units do not interfere. Concentration of amines in the ethylene glycol by liquid entrainment must be avoided to prevent difficulty in determining the titration endpoint. Carbon dioxide is inert to the Karl Fischer reagent.

The neutralization of hydrogen sulfide and mercaptan is performed prior to the Karl Fischer titration. This is accomplished by addition of approximately 1N iodine-in-methanol solution of known water content. The reaction products, mercaptan disulfide, hydrogen iodide, and free sulfur are inert to the Karl Fischer reagent under conditions obtained in this method. This has been proved experimentally by adding dry hydrogen sulfide and mercaptan to ethylene glycol of varying, but known, water content, neutralizing the hydrogen sulfide and mercaptan with iodine, and titrating with Karl Fischer reagent. The amount of water found was, in all tests, identical with the amount known to be in the iodine standard plus the amount in the glycol used.

TABLE 3. Saturation value for water vapor in nitrogen at high pressure.

Temp. F ± 0.3 Distilled H_2O	Pressure psia	Lb H_2O/MM cu ft (experimental)	Lb H_2O MM cu ft*
76.3	1000	27.0	27.9
55.9	1000	15.5	14.5

* Data from reference No. 9 were extrapolated for this range by F. C. Boston of the chemical engineering section.

Apparatus and Materials

The field apparatus for absorption of water vapor at high pressure is shown in Fig. 4 and consists of the following:

A—Glass wool mist extractor.
B—Grove regulator, Model 94.
C—Water absorber, cap., 400 ml. (See Fig. 3 for details.)
D—Gas meter, cap., 150 cu ft per hr.

Laboratory materials

Machlett automatic burette, with sealed-on ball joint, Fig. 5.
1—2000 ml reservoir for Karl Fischer reagent.
1—2000 ml reservoir for ethylene glycol.
1—1000 ml reservoir for water-in-methanol standard.
1—1000 ml reservoir for iodine-in-methanol reagent.
Flasks. 250 ml capacity, flat bottom with narrow neck, socket joint, and ball cap.
Magnetic stirrer. Magnetic stirrer, and stirring bars sealed in glass, or tygon.

Chemicals	Quality	Water Tolerance wt. %
Methanol	C. P., absolute	0.1
Iodine	C. P., resublimed	0.0
Pyridine	C. P.	0.1
Sulfur dioxide	99.5%	0.5
Ethylene glycol	C. P.	0.05

Reagents. Karl Fischer reagent, for water titration.
Water-in-methanol standard, for standardizing the Karl Fischer reagent (optional: sodium tartrate di-hydrate[11]).

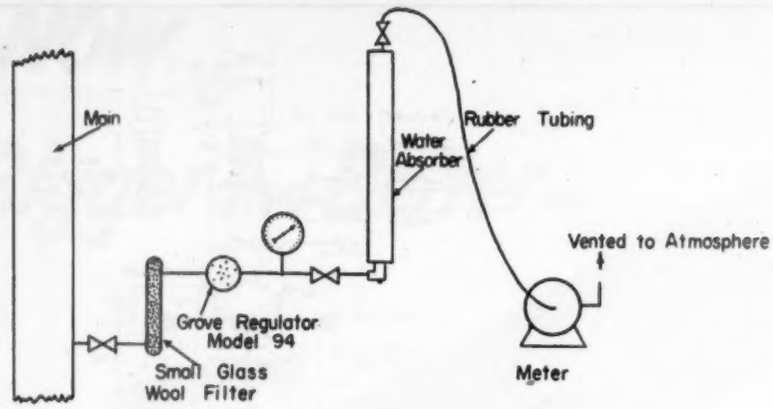

FIG 4. Field apparatus for absorption of water vapor in natural gas.

Iodine-in-methanol reagent, for neutralizing hydrogen sulfide and mercaptans.

The preparation and standardization of the reagents, in addition to a comprehensive description of the use of Karl Fischer reagent for general application to water determination, is thoroughly covered in a book entitled *Aquametry*.[17]

Procedure for water vapor determination on a high pressure gas system. Two hundred and fifty milliliters of ethylene glycol are delivered from a Machlett automatic burette directly into the water absorber, Fig. 3. The O-ring and cap are immediately positioned, and the bolts are tightened snugly. A glycol aliquot of approximately 50 ml is withdrawn through the exit valve and titrated with Karl Fischer reagent for water content. The remaining glycol, of the same water content, is left for water vapor absorption. Glycol remaining on the tip of the exit valve is removed with an ordinary pipe cleaner or other suitable absorbent.

The apparatus for water vapor absorption, with the exception of the absorber (Fig. 4) is set up at the test location and thoroughly purged to remove all liquid water upstream from the position of the absorber. If the apparatus has been properly dried beforehand, a purging time of 15 minutes should be sufficient. The absorber is then attached, and gas pressure is applied to the bottom of the absorber until the pressure gage indicates the selected operating pressure. The operating pressure should be approximately 15 per cent lower than the line pressure to compensate for small pressure fluctuations that may otherwise cause a back-up of glycol. A calculation of the effect of 0.05 ml of glycol trapped upstream from the absorber interior indicated that an error of approximately 25 per cent might be obtained for the water content. With careful technique, however, this can be avoided. The manner in which the inlet valve of the absorber is opened is important. With the outlet valve open, the inlet valve is turned just enough to give a gas flow rate of about 2 std cu ft per hour at the meter. After about 0.1 std cu ft of gas has been passed, the outlet valve is closed and pressure is allowed to build up in the absorber. The inlet valve is very slowly opened as the pressure approaches the operating pressure. When this pressure is nearly obtained, the outlet valve is adjusted to give the desired rate of gas flow. Absorption is continued for a period of time sufficient to absorb 100-300 mg water. Approximately 30 std cu ft of gas is required if the gas contains 7 lb H_2O per 1,000,000 cu ft.

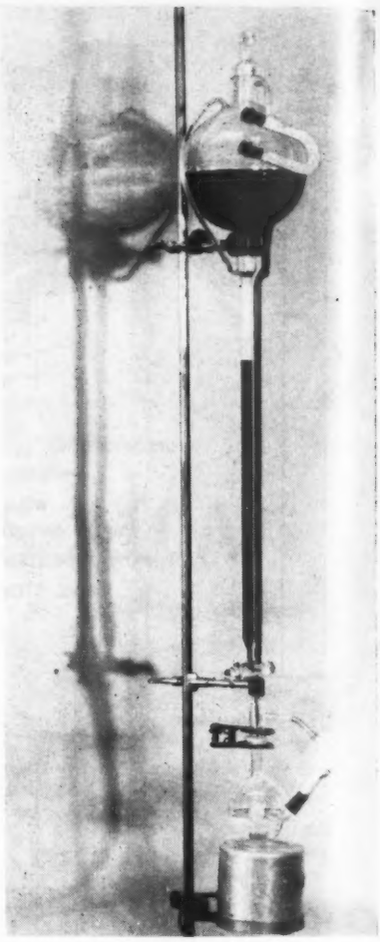

FIG. 5.

Water Determination

Pressure on the absorber is released at the outlet valve, and an aliquot of approximately 75-90 ml of glycol is withdrawn through the inlet valve into a tared titration flask containing a magnetic stirring bar. The ball cap is replaced and the flask is weighed to ±.01

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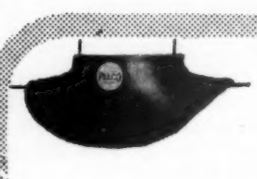

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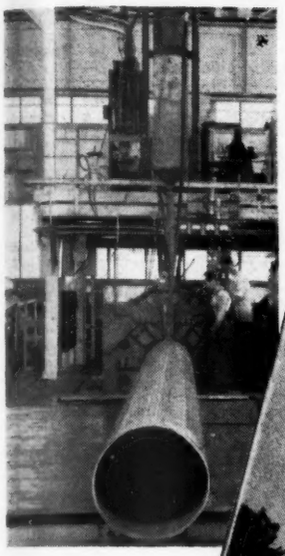

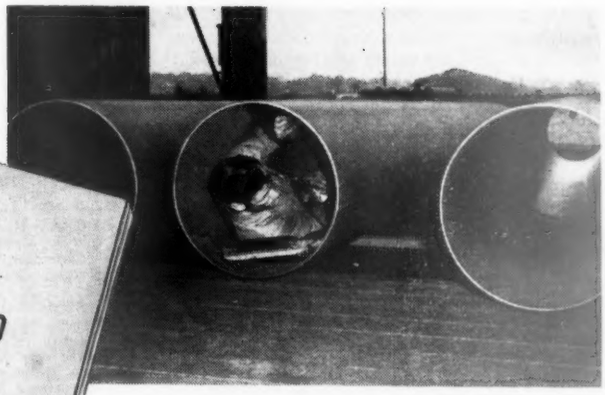

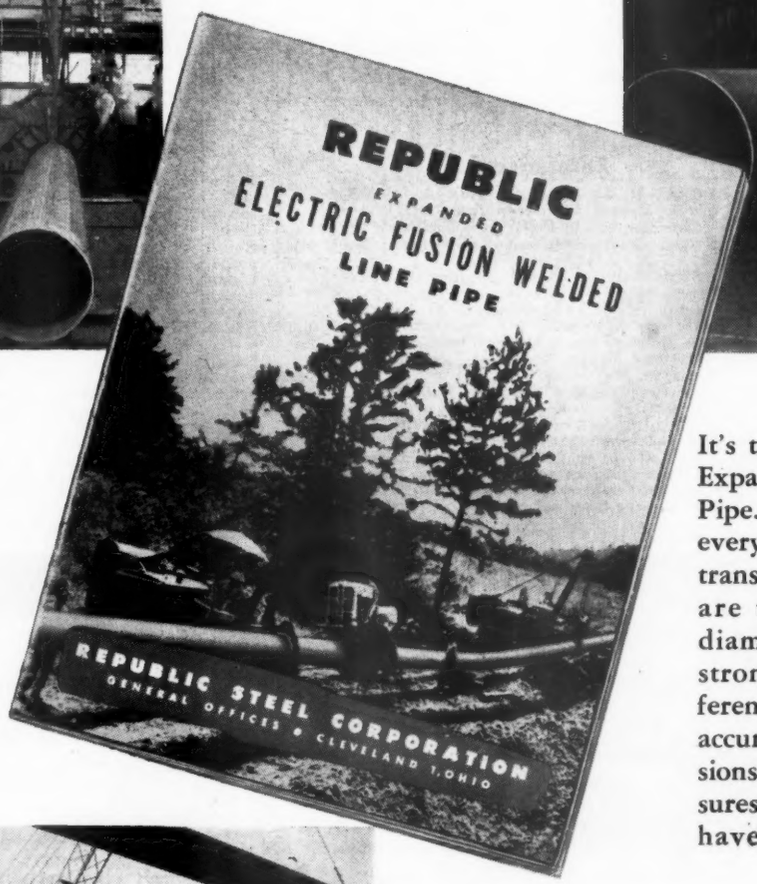

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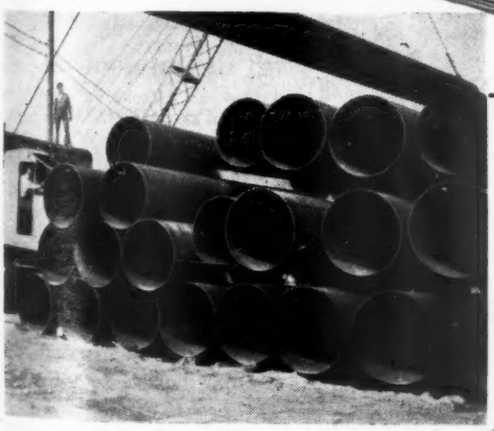

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gram. Hydrogen sulfide and mercaptan neutralization is accomplished by titration of the aliquot to the iodine endpoint with iodine reagent. Total water is then determined by direct titration with Karl Fischer reagent. Water added with the iodine titration, plus the known amount initially present in the glyycol, is subtracted to give the total water absorbed in the aliquot.

The water vapor concentration of the gas is then obtained by the following relationship:

$$\frac{W(2.2046)}{V} = \text{Lb } H_2O/\text{MM cu ft}$$

Where:

W = milligrams of water absorbed.
V = Volume of gas in cubic feet at 60 F and 14.7 psia.

The factor, 2.2046, is derived by conversion of milligrams of water per cubic foot to pounds of water per million cubic feet.

Summary

Application of ethylene glycol and Karl Fischer reagent to the determination of water vapor in natural gas has given satisfactory results under a wide range of conditions involving pressure, temperature, gas composition, and water vapor content. Over-all precision of the method is ± 1.2 lb with a mean standard deviation of 0.60 lb H_2O per 1,000,000 cu ft. Accuracy of the method is based on published data for the relative humidity of saturated salt solutions and for the saturation values for water vapor in gases at both low and high pressures. On this basis accuracy and precision of the method are synonymous. In practical application, where the water vapor conditioner is absent from the apparatus for absorption of water vapor, a higher degree of accuracy and precision may be expected.

Acknowledgment

The author is grateful to United Gas Corporation for permission to publish this work, to D. T. MacRoberts for originating the idea of applying Karl Fischer reagent to the method, and to those who have offered advice and criticism, especially F. C. Boston, Dr. W. M. Dow, and Dr. H. A. Palmer. Grateful acknowledgment is also due J. B. Hays for constructing the high pressure water absorber.

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Controlling Deterioration of Cooling Tower Lumber†

Double-diffusion treatment is considered best means of combating wood decay

DONALD R. BAKER*

THE lumber that is used in the construction of cooling towers is subject to various types of deterioration or alteration. These include: (1) erosion due to the impingement of falling water; (2) leaching, which is selective due to the wide variation in the solubility of the components in the wood; (3) chemical deterioration due to some of the components of the wood reacting with impurities in the water, and (4) decay due to micro-organisms that utilize the wood as food. An earlier paper[1] described the structure of wood in detail and explained these various types of attack.

The different types of attack are interrelated since they may occur simultaneously, or one type may precede or cause another. The purpose of this paper is to outline methods that the operator may adopt to minimize or prevent wood deterioration in cooling towers.

Chemical Deterioration

The cells making up the main body of wood consist of approximately 50 per cent pure or alpha-cellulose, 25 per cent hemicellulose, and 25 per cent lignin.

The cellulose and hemicellulose include a wide range of carbohydrates produced in the living plant by the elaboration of glucose. Their chemical composition is practically the same, the main difference being in the size of the molecule. Pure cellulose, which is the same as cotton fibers, has the highest molecular weight. It is quite stable and highly insoluble in water. As the size of the molecule decreases, the stability decreases and the solubility increases. All of the carbohydrates are hydrolyzed, or degraded, by acids, which convert them into less stable compounds.

Lignin is an amorphous compound of indefinite composition that is associated with the cellulose materials within the cell walls, and also as a binder between cells. It is highly insoluble in water, but is attacked by alkalies and oxidizing agents.

The cell cavities contain extraneous materials, or extractives, that may vary from 8 to 30 per cent of the dry weight of the wood, and average about 10 per cent in the case of redwood. These materials import the distinctive properties to each variety of wood. They are usually classified by their solubilities in hot and cold water, and in other solvents. The extractives give redwood its distinctive color, as well as its durability, since some of the components are toxic to wood-destroying organisms.

Leaching is the simplest form of chemical attack. The selective removal of the various constituents is influenced by the presence of impurities in the water. This was demonstrated by a series of tests conducted by the Forest Products Laboratory of the United States Department of Agriculture[2] to determine the effect of various solutions on the leaching and chemical deterioration of redwood. The solvents included distilled water and different strengths of solutions normally present in circulating waters. The effect of the various solutions on test blocks was determined by visual examination, chemical analysis and by decay tests. The visual examination showed varying differences between the effects of the various solvents, their concentration, and the length of exposure. The chemical analysis of the test blocks was none too satisfactory in evaluating the extent of deterioration of the wood. This difficulty was largely due to the chemical nature of wood and the standard methods used in analyzing wood. Distilled water will remove the water-soluble extractives. The presence of solvents in the water alters some of the constituents of the cell structure and produce additional water-soluble materials. The result was that in some instances the leaching actually increased the water-soluble extractives remaining in the wood as a result of this degrading action.

The decay tests proved to be a more reliable means of measuring and evaluating the extent of chemical deterioration. The reason for this is that any action that produces chemical deterioration will normally remove some of the toxic materials, resulting in a reduction in the resistance to decay.

These and other tests, indicate that:

(1) Distilled water will remove the toxic extractives from redwood.

(2) The presence of alkalies or oxidizing agents will accelerate this action.

(3) These two conditions contribute to chemical deterioration of the wood structure.

(4) Alkalies attack the lignin of the wood, producing the type of attack called delignification.

(5) Oxidizing agents react with the tannins that make one group of toxic extractives in many woods, including redwood. They also degrade the cellulosic constituents.

(6) Acids hydrolyze and degrade the cellulosic constituents of wood. This converts the insoluble cellulose into more soluble compounds approaching glucose. Extreme cases may darken the wood and eventually reduce it to a charred condition.

The various laboratory tests serve the incidental purpose of demonstrating that leaching or chemical attack renders the wood more susceptible to decay. Both chemical attack and decay reduce the structural strength of wood, and the loss of strength usually occurs before any visual signs of deterioration become apparent. This last fact is quite important because it offers a means of detecting deterioration in its early stages.

Control of Chemical Deterioration

The cooling tower operator cannot prevent the normal leaching of the water-soluble extractives from the wood. It is possible to hold this leaching to a minimum by proper treatment of the circulating water. The leaching does not seriously affect the structural strength of the lumber, but conditions that accelerate the leaching usually also result in chemical deterioration and a loss of both cross-sectional area and structural strength. Circulating water is treated to prevent the deposition of scale on heat transfer surfaces, prevent corrosion of metals within the system, kill microorganisms that foul the circulating system, and prevent wood deterioration. The latter has seldom been considered in the past, and water treating practices are often selected to control scale and corrosion with little regard to the resulting effect on the wood in the cooling tower.

The usual practice in the past has been to maintain the circulating water on the alkaline side to prevent corrosion, but not high enough to produce scale. That is the basis of the method presented by Langelier. The use of surface-active agents will allow even higher alkalinities without depositing scale, but these approaches do not consider the effect on the wood. The result has been that the pH value has usually been above neutral, averaging around 8 and often being as high as 10 or more, which is detrimental from the standpoint of chemical deterioration. The optimum pH value for redwood is about 6.5 if only chemical attack is considered, but a pH value on the acid side is more favorable to decay. Taking all factors into consideration, the Cooling Tower Institute recommends a pH value between 6.5 and 7.5 as the optimum for cooling tower lumber.

†Presented at Petroleum Engineering Conference, American Society of Mechanical Engineers, Kansas City, Missouri, September 22-24, 952.

*Engineering research department, The Marley Company, Inc.

It should be understood that the pH value by itself cannot be taken as an indication of possible chemical deterioration or of the extent of the possible attack. It is the constituents in the water producing the pH, and not the pH value itself, that causes the deterioration. Neither is the pH value a measure of the concentration of the dissolved solids, so both the constituents and their concentrations must be taken into consideration. This can be determined only by a complete chemical analysis of the water.

Chemical deterioration of cooling tower lumber is often referred to as delignification, although the word does not describe the action in the strictest sense in any case, and may be completely misleading. The word indicates a pulping process similar to that used in the manufacture of paper when the lignin binder is removed from the wood fibers. Even in the paper industry, pulping agents are not available that will remove the lignin without also attacking the other components of the wood to some extent. The impurities present in circulating waters are poor pulping agents so also remove hemicellulose as well as lignin, and probably degrade the cellulose. In some instances this produces loose cellulose fibers on the surface of the wood that is typically referred to as delignification. This condition usually occurs in parts of the tower that are alternately wet and dry. In other instances, and often in other parts of the same tower, the attack merely softens the outer shell of the wood, or produces a porous, corky mass on the surface.

The presence of sodium carbonate in the circulating water is generally considered to be the principal cause of delignification. Various references state that the bicarbonate is not detrimental, but the experience of the author indicates that the presence of either is about equally effective in producing delignification. Instances are cited[3] to show that lowering the pH value below 8.2, where the normal carbonate should be converted to bicarbonate, has not prevented delignification. Some operators using water containing sodium carbonate have controlled the attack by holding the pH value below 8.2 while also maintaining a methyl orange alkalinity below 100 ppm by the addition of sulfuric acid. Such an approach recognizes the effect of the concentration, as well as the character of the constituents, but the maximum allowable alkalinity will probably vary from plant to plant.

Oxidizing agents used as an algicide can attack the wood if used excessively, and a few isolated instances have been reported where chlorine has attacked the wood. Chemical attack is usually evident from a visual inspection of the wood in the tower. Any sign of chemical attack is a signal to determine the chemical composition of the water and adopt a water treatment that will correct the situation. Chemical attack usually accelerates the rate of leaching, with the result that the toxic extractives are removed and the wood rendered susceptible to decay.

Decay is a type of deterioration caused by wood-destroying fungi that utilizes the wood as food, so is actually another form of chemical deterioration. It is commonly called rotting and the two terms are synonymous. Durable varieties of wood, such as redwood, contain toxic extractives that prevent the growth of the organisms. The growth cannot occur without the presence of oxygen and also moisture in excess of fiber-saturation. The latter means that the fibers must be saturated with moisture, and have some excess water in the cell cavities. Dry wood does not decay, and the fungi cannot grow in water-logged or submerged wood because oxygen is excluded. The lumber in a cooling tower varies in moisture content from dry to water-logged and the decay of cooling tower lumber, strangely, usually occurs in wood that would normally be considered too wet to be attacked. The explanation for this may be that the normal redwood is sufficiently toxic to resist the fungi, but the natural preservatives are leached out of the wood that becomes water-logged, and the aeration occurring in a cooling tower provides sufficient oxygen to support the fungus.

The first incidence of wood deterioration to be identified as decay was reported in May, 1948. Records have been kept since that date of all installations reporting decay, and less than 50 cooling towers have been listed. Decay undoubtedly occurred prior to 1948 that was not reported or identified as chemical deterioration. It is also true that all instances of attack have not been reported, but the records do indicate that decay can be considered the exception rather than the rule. Nearly half of the reported cases are in the Gulf Coast area where decay should be more prevalent due to the warm climate and long growing season. It must also be understood that there is a large concentration of cooling towers in that area, and also several intensive surveys have been made to locate infected towers in that area. The balance of the infected towers seem to be rather equally distributed throughout the United States, and it is interesting to note that the Forest Products Research Laboratory of England has recently become involved in the same problem.

The survey does not indicate that infection is confined to any particular type, make or part of a cooling tower. The first instances of attack were found in parts that are not flooded with water, such as the eliminators or sections beyond the eliminators. Infected wood in these places appears normal on the surface with the rotting occurring below the surface, which is the usual pattern of attack. Deterioration in other parts of the towers that had formerly been considered as chemical attack has since been identified as decay. Such lumber is usually found in flooded portions of a cooling tower when the deterioration occurs on the surface, and this was formerly assumed to be the result of chemical deterioration. Specimens of lumber having this type of attack from the filling of two cooling towers were submitted to the Forest Products Laboratory in the fall of 1949. The Laboratory found the same fungus, poria nigrescens, in this wood that had previously been isolated from cooling tower lumber having typical decay. It has since been established by the Forest Products Laboratory, as well as other investigators, that much of the deterioration on the surface of cooling tower lumber is due to biological attack. It may be of only academic interest that the same organism has been isolated from both types of biological attack. Of importance is the fact that decay in one portion of a tower can spread to other parts quite easily if the same organism is involved.

Decay on the surface of the wood closely resembles chemical attack, so differentiation cannot be made by visual inspection. A laboratory examination is necessary to determine whether wood-destroying organisms are present, and even then it is seldom possible to determine how much of the deterioration is due to chemical attack and how much has been caused by the organisms. It is difficult to detect incipient decay except by careful examination in the laboratory. Like chemical attack, it usually produces a condition of brashness before any visual signs of decay are evident. Brashness in wood is a condition of brittleness due to a loss of strength. It may be detected by breaking the wood and noting the type of fracture. Normal wood fails progressively by a series of breaks across the grain, accompanied by splitting along the grain. Brash wood usually fails with a single break square across the grain. Experience makes it possible to predict with a fair degree of accuracy whether wood-destroying organisms are present.

Chemical attack can be controlled by treatment of the circulating water, but this will not stop biological attack. Unless the attack is obviously the result of chemical deterioration, it is desirable to have the wood examined biologically to determine whether wood-destroying fungi are present.

Wood Preservation

Wood in its natural state provides a satisfactory structural material in many applications. A preservative treatment may be applied when the lumber is used in services where decay is prevalent. There are numerous treatments available that are effective so long as they remain in the wood. The effectiveness, as well as permanence, is determined largely by the depth of penetration and the amount of preservative impregnated into the wood. The preservatives may be roughly divided into two classes: Those soluble in oil or in water. They may be applied by such superficial means as by brushing or dipping, or by pressure treatment applied within a closed container.

Pressure treatments result in deeper penetration and so are preferable. Preservatives soluble in water are subject to leaching so their value is doubtful when used in services such as that existing in a cooling tower. Some treatments are soluble in water when applied but

react within the wood to form insoluble compounds that resist leaching.

The conditions existing in a cooling tower preclude the use of water-soluble salts or superficial treating methods that do not give a deep penetration of the chemical into the wood. Few cooling towers in the past have been constructed of treated wood so service tests of the more promising treatments are not available. The incidence of decay in cooling tower lumber is actually rare so the vast majority of untreated towers give satisfactory service. A purchaser desiring extra protection may specify the use of pressure-treated lumber. Other than avoiding water-soluble treatments, there is little advice that can be given at the present time in selecting the best type of treatment. Service tests have been started within the last few years, including some accelerated tests, but no results can be expected from them for a number of years.

Treatment of Cooling Towers

Most purchasers are reluctant to buy cooling towers constructed of treated lumber because of the added expense. When decay occurs, the owner immediately asks what can be done to stop the attack. Unlike chemical attack, decay can progress to an advanced stage before it is detected, as already explained. Once present, it cannot be stopped by changing the water treatment. Up to a year ago, no method was available for combating decay in existing cooling towers. The only recommendation was to inspect the tower regularly and replace all infected wood. A method has been developed during the last year that offers a means of control. It utilizes a number of unrelated processes and adapts them to the particular problem. The various steps have been checked by a series of laboratory tests, and one full-scale field test has been made.

It has already been pointed out that various water-soluble chemicals will control decay. Such materials might be introduced into the circulating water, but the quantity of water involved and concentrations required usually make the cost prohibitive. This method becomes more attractive if it is possible to take the cooling tower out of service and circulate a small quantity of the concentrated solution. The treatment may be applied to dry lumber, in which case the preservative is carried in as the solution penetrates the wood, and it may be used with materials carried in oil or water. Wood does not have the affinity for oil that it does for water so the penetration is much less when oil is used as the carrier.

Contrary to popular feeling, water soaks into dry wood quite slowly; however, dissolved solids will diffuse from a solution into water-logged wood much faster than the solution will penetrate dry wood. The Forest Products Laboratory has utilized this fact in developing a method for treating green fence posts that is known as the double-diffusion treatment. The treatment uses two soluble salts that are diffused into the wood separately. They react within the wood to form insoluble compounds that are toxic to the fungi. Various combinations of salts were used by the laboratory in a service test that was begun in 1942. The pine posts used in the experiment had a life expectancy of 3 years when not treated, and no failures have been found after 10 years' exposure. The usual service test continues for at least 20 years, so the results have not been published to date.

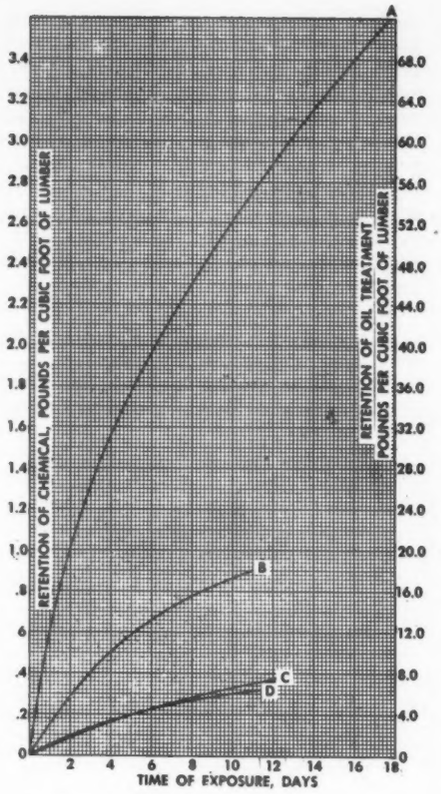

FIG. 1. Absorption of treatment by well and dry wood.

A series of laboratory tests were run during the last year using redwood blocks 0.94 in. by 1.69 in. by 4.94 in. to determine the penetration of various treatments by both diffusion into wet wood and soaking into dry wood. The blocks were wrapped in absorbent cotton and suspended over the solution with only the cotton touching the liquid. This arrangement simulated actual conditions that would occur during the treatment of a cooling tower by keeping the surface of the wood wet without submergence in the solution. The results of these tests are shown graphically in Fig. 1. Curve A shows the rate of diffusion of copper sulphate from a concentrated solution into water-logged redwood. The scale at the left shows the absorption of salt in pounds per cubic foot of wood. By contrast, Curve B shows the absorption of copper sulphate by a dry block of wood. It will be noted that a retention of 0.5 lb per cubic foot was obtained in 22 hr when diffusing from a concentrated solution into water-logged wood, while the same retention required nearly four days when dry wood was used. The test shown in Curve A was continued for 18 days at which time the block had a retention of 3.5 lb per cu ft.

Curve C shows the absorption of sodium chromate following an 11-day exposure of a dry block to the copper sulphate solution. Considering this as an extension of Curve B, it will be noted that the rate of absorption continues to diminish with time. Changing the solution had little effect on the rate, indicating that the absorption depends almost entirely on the absorption of the water by the wood.

A similar block of dry wood was immersed in an oil solution containing 5 per cent chlorophenol, and the rate of absorption is shown by Curve D. Following the standard practice used in the wood-treating industry for treatments carried in oil, the retention is shown as pounds of solution per cubic foot of wood on the scale at the right. The scale on the left also shows the absorption of pentachlorophenol itself since that scale is 5 per cent of the one on the right. Using the scale at the left to compare Curve D with Curve B shows that the absorption of pentachlorophenol by the dry block is much slower than the absorption of a water-soluble salt. Comparing Curve D with Curve C shows that the absorption of a dry block from an oil solution is approximately equal to the absorption of a water solution after the first 11 days.

These laboratory tests show that a salt will diffuse from a solution into water-logged wood at a much faster rate than the solution will penetrate dry wood. They also show that a water solution is absorbed faster than oil.

A heavy commercial treatment will seldom have a retention of more than 20 lb per cubic foot of oil or 1 lb per cubic foot of salt, with retentions of half those amounts being considered adequate for severe exposures. The laboratory tests indicate a definite advantage for the diffusion of salt into wet wood. A retention of 0.5 lb per cubic foot was obtained in one day by diffusion into wet wood while it took 4 days with dry wood. A soaking of 11 days resulted in a retention of only 0.3 lb of pentachlorophenol when the oil carrier was used.

Double-Diffusion

The Forest Products Laboratory has tested various combinations of salts for use with the double-diffusion treatment, and the most promising appear to be:

(1) A mixture of 6 parts zinc sulfate and one part arsenic acid in the first solution, followed by a sodium chromate solution.

(2) The same as above, except copper sulphate is substituted for zinc sulfate. This is approximately the same as the commercial treatment known as Greensalt or Erdalith. The copper salt is less desirable because it is more corrosive to the metal parts of the cooling tower. The treatment may be more toxic to fungi, but service tests must be made to determine whether the additional protection is necessary.

(3) Copper sulphate followed by sodium chromate.

(4) Sodium pentachlorophenolate followed by copper sulfate.

(5) A single solution containing:

Cupric hydroxide	58 per cent
Arsenic trioxide	39 per cent
Ammonia	3 per cent
Acetic acid	trace

This is the composition of the commercial Chemonite treatment. The salts are rendered soluble by the presence of ammonia, which later evaporates and precipitates them.

(6) Copper sulfate followed by sodium fluoride. The latter has a high rate of diffusion, but its solubility is only about 4 per cent at normal temperatures. The combination appeared good when used on fence posts at the Forest Products Laboratory, but in other tests the sodium fluoride solution seemed to leach the copper sulfate out of the wood.

All combinations except (5) consist of two solutions that are applied separately, but react to deposit insoluble precipitates within the wood. The single treatment described in (5) has the advantage of reducing the time required to apply the preservative. Ammonia is corrosive to copper alloys, which may be a disadvantage when those materials are present. The concentration involved does not indicate a severe hazard but trial runs may be advisable before the treatment is applied.

Method of Application

Any method of application that will keep the surface of the wood wet should be successful. This may be accomplished by circulating a small amount of solution over the tower. This may require the installation of a temporary distribution system if corrosive materials are handled. An alternate method requiring less material is to spray or fog the treating solution into the tower. In this case, the fans may be operated forward or reverse to help distribute the treatment. The addition of wetting agents to the solution offers possibilities. Careful application makes it possible to treat sections of a tower without seriously contaminating the water in the system. Considerable water is held up in a tower when the circulation is stopped so it may be just as satisfactory to apply the treating solution intermittently.

Most of the materials involved are classified as poisonous and may irritate the skin. The same is true of many chemicals commonly used in water treatment, so no great hazard is involved if the proper precautions are taken.

Infected parts of several installations have been treated by spraying. One multi-cell induced draft tower has been treated by circulating copper sulfate followed by sodium chromate. The tower was taken out of service and temporary bulkheads installed to separate the fan cells. The copper sulfate solution was circulated over each cell for 48 hr and then allowed an additional 48 hr to diffuse into the wood before the sodium chromate solution was circulated for the same length of time. The procedure was adopted primarily to treat the filling, with only a slight effort made to treat the eliminators and structural members between them and the fan.

Pieces of wood were removed from various parts of the tower after treating and sent to the Forest Products Laboratory for examination and analysis. Only specimens having a large cross-sectional area were selected for analysis so that the penetration into the parts getting the poorest treatment could be determined. An analysis was made of the outer ½-in. shell of each specimen. A second analysis was made of the core of each piece after the outer shell had been removed. The results are shown in Table 1.

The letter transmitting this information[4] also said in part:

"It will be observed that the core samples showed only traces of either chemical.

"The outer half inch of most pieces showed retentions within the range of the customary retentions used in commercial treatments with water-borne preservatives. The ratio of chromate to copper was very satisfactory.

"The analyses showed that a fairly satisfactory treatment had been obtained, although a deeper penetration of these thick pieces would be desirable if it could be achieved by a practical schedule of treatments. It is possible that the ingress of chemicals is hindered somewhat by the extractives of the redwood. In addition to tending to reduce the effective sizes of capillary openings, they react chemically with copper salts and with chromates."

Thin sections of wood are more easily treated than thicker sections so, naturally, get a higher retention of chemicals for a given method of application. These thinner sections also need a heavier treatment because the preservatives and natural extractives will be removed by leaching at a faster rate. The result is that lumber needing the most protection will get the heaviest treatment and the most uniform penetration.

Conclusions

The rate of chemical deterioration of cooling tower lumber is determined by the constituents dissolved in the circulating water. These may be controlled by water treatment. The pH value serves as an indication of the conditions of the water but must not be taken as the sole point of control. As a general rule, the pH value should be maintained between 6.5 and 7.5 to minimize chemical deterioration, but deterioration can occur when operating within the optimum range. The control of both alkalinity and pH value offers a more realistic approach. The presence of sodium carbonate should be avoided by the use of sulfuric acid to convert these salts to the sulfate.

Decay is far less common than chemical attack. Its incidence cannot be so easily explained and neither can it be controlled or stopped by water treatment. Decay has been reported in only a small percentage of the cooling towers in operation, although it is probably more prevalent than generally realized. There is little likelihood that treated lumber will be adopted as standard practice in the near future, and there is no positive indication that such protection is needed.

The small chance of attack does not alleviate the problem of an operator when it does occur. The double-diffusion treatment offers such an operator the means of controlling the attack. It offers a means of preventing infection, and may also stop the spread of any fungus that is present in the wood. The lumber in a cooling tower becomes water-logged soon after the equipment is put in operation. The unique conditions existing in a cooling tower present one of the few instances where the double-diffusion treatment seems applicable and practical.

The treating may be accomplished by the use of any of the combinations described in this paper. Each of them should be effective, but their relative merits can be determined only by actual field tests. A cooling tower may be operated a year or two without treatment as infection seldom occurs in that length of time. The treatment may then be applied, or it may be used only after incipient infection is discovered. A chemical analysis will indicate the amount of chemical retained by the wood, and treatment can be repeated when or as needed. The amount of chemicals needed to treat a tower can be calculated by determining the amount of lumber in the tower. A salt retention of 0.5 lb per cubic foot is considered a good commercial treatment. When two soluble salts are used that form an insoluble compound within the wood, a sufficient quantity of each must be used to provide the 0.5 lb of the insoluble precipitate per cubic foot of lumber.

TABLE 1.

Sample No.	Description	Absorption of chemicals: $CuSO_4$ lb per cu ft	Na_2CrO_4 lb per cu ft	Total lb per cu ft
	Outer ½-in. shell			
1-O	2x4 column splice piece	0.148	0.182	0.33
2-O	2x4 column splice piece	0.274	0.283	0.56
3-O	2x4 column splice piece	0.254	0.291	0.55
4-O	2x4 column splice piece	0.179	0.204	0.38
5-O	4x4 stringer splice piece	0.191	0.185	0.38
6-O	4x4 stringer splice piece	0.342	0.342	0.68
7-O	4x4 stringer splice piece	0.260	0.216	0.48
8-O	4x4 stringer splice piece	0.222	0.204	0.43
9-O	4x4 fan beam block	0.179	0.123	0.30
10-O	4x4 fan beam block	0.073	0.132	0.21
	Inner core			
1-C	2x4 column splice piece	0.003	0.003	0.006
2-C	2x4 column splice piece	0.003	0.003	0.006
3-C	2x4 column splice piece	0.006	0.003	0.009
4-C	2x4 column splice piece	0.006	0.002	0.008
5-C	4x4 stringer splice piece	0.03	0.002	0.032
6-C	4x4 stringer splice piece	0.008	0.005	0.013
7-C	4x4 stringer splice piece	0.008	0.003	0.011
8-C	4x4 stringer splice piece	0.003	0.003	0.006
9-C	4x4 fan beam block	0.01	0.006	0.016
10-C	4x4 fan beam block	0.003	0.005	0.008

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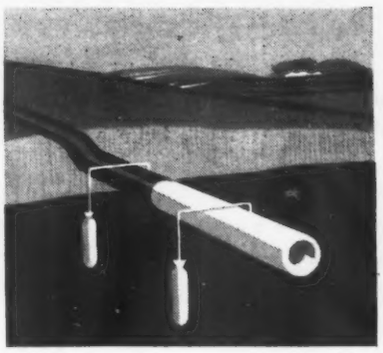
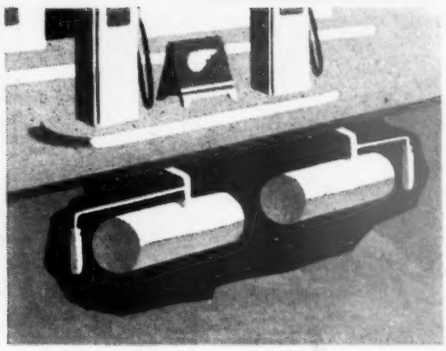
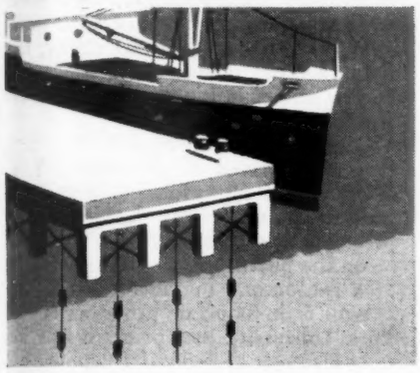
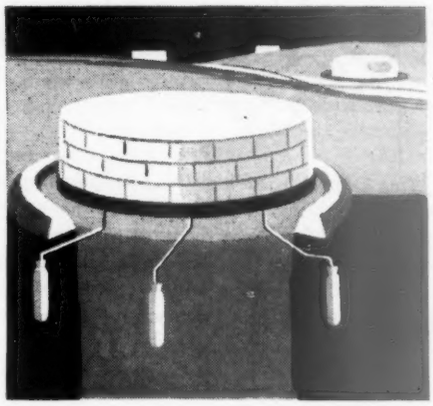
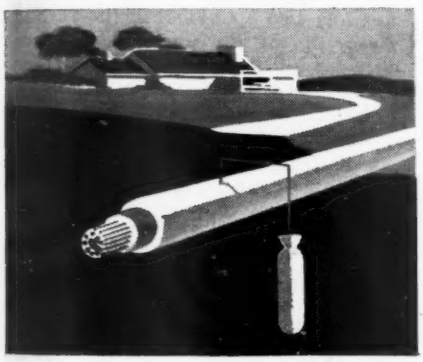


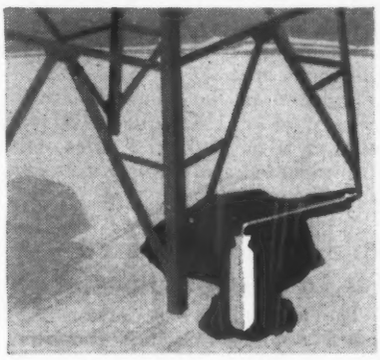


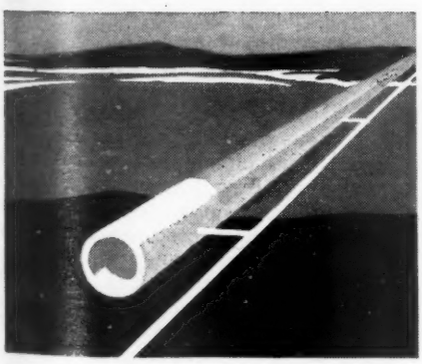


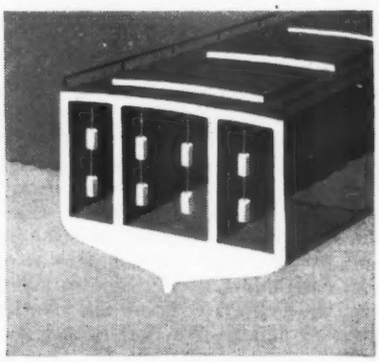
DOW magnesium anodes











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This map illustrates the expansion program planned by Southern Natural Gas Company during 1952-53. The solid lines show the location of loops and new lines to be constructed by Houston Contracting Company, Ltd., and H. C. Price Co. The dotted line indicates Southern Natural's existing route, along with proposed construction west of the Mississippi River and south of Lake Pontchartrain, plus its South Carolina extension.

Southern Natural Awards Contracts for 833 Miles of Lines

Houston Contracting Company, Ltd., of Houston, Texas, and H. C. Price Company of Bartlesville, Oklahoma, have been awarded contracts by Southern Natural Gas Company of Birmingham, Alabama, covering the construction of 833.4 miles of loop and new lines in Louisiana, Mississippi, Alabama, Georgia, and South Carolina.

Work contracted by the two construction companies covers an important phase of the $76,000,000 construction program planned by Southern Natural during the next three years. The 1254 miles of new pipe line and 22,250 compressor horsepower to be added to Southern Natural's present system will enable the company to increase its daily delivery of natural gas to 1,020,000,000 cu ft by 1954.

Two spreads of Houston equipment were scheduled to begin work on 88 miles of main line loops the latter part of October. This portion of the Southern Natural project recently received an emergency authorization by the Federal Power Commission. Hearings are in progress on the balance of the program, and a permit from the FPC is expected in the near future.

It is contemplated that the Price company will have two spreads in action on the Southern Natural job early next year, while a total of four crews will be assigned to the project by Houston Contracting next year. Completion date for the entire 833 miles is scheduled for December 1, 1953.

Contracts negotiated by Houston and Price cover the entire 1952-53 phase of Southern's expansion program with the exception of lines west of the Mississippi River and south of Lake Pontchartrain in Southeastern Louisiana. Aside from the 88 miles to be built by Houston this year, the remainder of the main line loops will be constructed by the Price organization. This portion of the right-of-way includes a mountainous stretch in northern Alabama and Georgia, which is a heavily timbered and rocky area.

Included in the contracts are 353.3 miles of 24-in., 114.9 miles of 20-in., 239 miles of 16-in., and 127.3 miles of 14-in. Also included are multiple crossings of 16 major rivers.

Rule Change Proposed For Rate Applications

The Federal Power Commission has issued a notice that it is proposing to adopt a new general rule that would replace the existing rule governing the filing of rate increase applications by natural gas companies.

The proposed new rule is designed to set forth the requirements for the basic data to be submitted by a natural gas company, upon which it relies for support of its rate increase application. Principally, the new rule would provide for more complete support of the application than under the existing rule, and would permit the company to present cost data reflecting known changes becoming effective within six months of the last month of actual experience.

The commission recently has been confronted with a tremendous increase in natural gas rate applications, with the total dollar amount of increases filed in the fiscal year 1952 representing a six-fold gain over fiscal 1951, and an increase of more than 200 times over the 1949 total. The new rule would provide for the inclusion in applications of data that would facilitate the evaluation of rate increase proposals.

Interested persons have until November 21, 1952, to submit to the FPC in writing views and comments concerning the proposed amendments.

Microwave Services, Inc. New Engineering Firm

Formation of Microwave Services, Inc., has been announced by Sidney K. Wolf, president. The corporation will provide consulting and construction services in the field of telecommunication. It will have an initial capital of $25,000 and will provide complete engineering services including system analysis, specifications, purchasing, installation, and supervision of plant facilities, and provide management services in the operation of all types of telecommunication systems, it is announced. These services will fit the needs of industry and government on a worldwide basis and will include such varied fields as petroleum, public utility, railroad, airline, telephone, broadcasting, and all phases of the national, state, and city governments.

Corporation is headed by Dr. S. J. Begun, chairman of the board; S. K. Wolf, president; Emile Labin, vice president, and Victor J. Nexon, vice president and treasurer, all of whom will be on the board, which will also include Max Delson and F. Vinton Long.

Wolf is an associate professor at New York University and prior to this was sales manager at Federal Telephone and Radio Corporation, a subsidiary of International Telephone and Telegraph. He was also a Colonel in the U. S. Air Force during the war and was deputy director of the radio and radar division of the War Production Board.

Labin was associated with International Telephone and Telegraph where for 16 years he was in various executive capacities concerning research and development of telecommunication systems and apparatus.

Nexon was associated with Federal Telephone and Radio Corporation and was project and sales engineer for the microwave communication system for the Texas Eastern Gas Transmission Pipe Line Corporation, one of the largest such projects in the world.

New Compressor Units Raise Transco's Capacity

Transcontinental Gas Pipe Line Corporation, which supplies natural gas to New York, New Jersey, and Philadelphia utilities, announces that completion of additional compressor units has increased its daily delivery capacity to the authorized maximum of 555,000,000 cu ft. All presently certificated 259,210 hp capacity became available when the third steam centrifugal unit at Eunice, Louisiana, station went into service.

Five new customers in southern states recently began taking gas from Transcontinental's line. These include Duke Power Company at Williamston, South Carolina, Piedmont Natural Gas Company at Greenville, South Carolina, Mid-Georgia Gas Company at Conyers, Georgia, Frederick Gas Company at Frederick, Maryland, and Laurens Glass Works, Laurens, South Carolina.

Beginning in September, Transcontinental's actual deliveries average substantially above 500,000,000 cu ft a day.

C-R-C Engineering Enlarges Its Staff For New Contract

J. P. Bristow

F. E. Hangs

W. T. Pyott

J. C. Graper

E. L. Beeman

With the awarding of the contract for designing of U. S. Pipe Line Company's giant new pipe line to carry refined petroleum products from Texas Gulf refineries to the East Coast, C-R-C Engineering Company, Houston, Texas, has announced plans for enlarging its staff to include some of the top pipe line engineers in the country.

The new pipe line will be the largest, longest, and costliest products line in the United States, it is asserted. In addition to carrying refined petroleum products such as gasoline, kerosine, and heating oil to East Coast markets and many intermediate points, a branch will help power the AEC's $1.2 billion uranium plant in Paducah, Kentucky.

New additions to the staff, announced by Herb E. Fisher, managing director and co-owner of C-R-C, include J. P. Bristow, Frank Edward Hangs, W. T. Pyott, John C. Graper, and E. L. "Roy" Beeman.

Bristow has been active in the engineering design, construction, and operation of pipe lines for more than 25 years. While serving as vice president and project manager of Fish Pipe Line Construction Corporation he handled engineering for Fish under the contract with Texas Illinois Natural Gas Pipeline Company for the construction of the pipe line from South Texas to Chicago.

From 1943 until 1949, Bristow was associated with Tennessee Gas Transmission Company and was directly in charge of engineering and construction of the TGT line and later for additions to the line that amounted to more than 2000 miles.

Prior to joining Tennessee Gas, Bristow was chief engineer for Northern Natural Gas Company and was in charge of engineering and construction for more than 300 miles of pipe lines varying in size up to 26 in.

Bristow first entered the pipe line construction field in 1926 when he was field engineer in charge of the location and construction of the first large natural gas pipe line, which was constructed by Interstate Gas Pipe Line Company from Monroe to Baton Rouge, Louisiana. In addition, he has served as field engineer for Southern Natural Gas Company and spent several years as senior valuation engineer with the Texas Railroad Commission during which time he observed various pipe line practices with respect to location and construction.

Hangs joins C-R-C from Transcontinental Gas Pipe Line Corporation where he was senior mechanical engineer for the design and operation of compressor stations. From 1946 to 1950, he was senior mechanical engineer and project engineer for The Texas Pipe Line Company. He joined Texas Pipe Line in 1933 as a mechanical engineer in pipe line design.

While attending the University of Illinois, Hangs served as part time draftsman and designer in the mechanical engineering lab at the university. He received his master of science degree in 1933.

Hangs was an officer in the Corps of Engineers, U. S. Army, from 1940 to 1946. During that time, he served as a professor of military science and tactics at Texas Tech and as a petroleum officer in the China-Burma-India theater. He was a lieutenant-colonel when he was discharged in 1946. He also served as an associate professor of mechanical engineering at the University of Houston.

Pyott was formerly chief engineer for Mannix, Ltd., in Calgary, Alberta, Canada. Before joining the Canadian company in 1949, he was assistant chief engineer for Great Lakes Pipe Line Company from 1941 until 1949 and corrosion engineer from 1935 to 1941. He received his master of science degree from Oklahoma University in 1935 and his bachelor's from Yale University in 1933.

A mechanical engineering graduate of Purdue University, Graper served in the products pipe line department of Standard Oil Company (Indiana) for five years. While with Standard Oil, he did design drafting, field surveying, economic analysis of proposed pipe line projects, and was supervisor of scheduling and dispatching.

Beeman was associated with the National Cooperative Refinery Association at McPherson, Kansas, for 9 years before joining C-R-C. He served first as traffic manager and later as manager of the distribution division, which handled all sales, movement of products, pipe line terminal operations, and traffic. At one time he was superintendent of highway transportation and pipe line terminal traffic for Globe Oil and Refining Company and has also served with the C. W. Kelly Transport Company, Kansas Corporation Commission, and the Union Pacific Railroad.

New Bulletin on Lincoln School of Welding

A new bulletin has just been published by The Lincoln Electric Company, Cleveland, Ohio, descriptive of the Lincoln School of Welding, the various course given, and the school's facilities.

Art Madson, head of the Lincoln School of Welding, knows more welding operators than any other man in the world. Head of the School for 25 of its 35 years of continuous operation, Art is the unofficial head of an international brotherhood of welding operators who have graduated from the School. The 35,000 men and women who have gone through the school in Cleveland have come from 19 different countries, from as far away as India and South Africa.

The school was started in 1917 when the United States Army purchased some welding equipment from Lincoln and specified in the purchase that Lincoln train soldiers to be welders. Since that time the school has been turning out professional welders for industry at a rate averaging better than 1000 a year. During World War II the school operated 24 hours a day with 4 separate classes being taught during each 24 hours.

The basic course at the Lincoln School consists of 4 weeks' training and practice with a new class starting every week. Lincoln conducts the school as a service to industry and only a nominal charge for materials is made. Advance courses in special welding techniques such as pipe welding and sheet metal welding are also available.

$14,737,400 Per Year Rate Increases Asked

Applications for wholesale natural gas rate increases totaling approximately $14,737,400 per year have been filed recently with the Federal Power Commission by 7 natural gas companies.

The companies, and the amounts of the proposed increases, are: Transcontinental Gas Pipe Line Corporation, of Houston, Texas, $9,800,000; United Gas Pipe Line Company, of Shreveport, Louisiana, $131,200; Colorado Interstate Gas Company, of Colorado Springs, Colorado; $375,200; South Jersey Gas Company, of Newark, New Jersey, $57,000; Tennessee Natural Gas Lines, Inc., of Nashville, Tennessee, $388,000; Natural Gas Pipeline Company of America, of Chicago, Illinois, $3,500,000; and East Tennessee Natural Gas Company, of Knoxville, Tennessee, $486,000.

American Gas Association Revises Its Constitution

An overwhelming majority of its members has approved revisions of the Constitution and By-Laws of the American Gas Association. The new Constitution and By-Laws, which removes ambiguous and outmoded requirements of the old one, will become effective two weeks after the adjournment of the AGA annual meeting in Atlantic City, New Jersey, on October 30.

Changes in the new document include the repeal of separate by-laws with the essential provisions of the former by-laws becoming part of the new Constitution and By-Laws. Objects of the association have been reduced from 9 to 7. Membership classes of AGA have been re-defined for clarity.

Among the principal provisions of the revised Constitutions and By-Laws is the elimination of the manufactured gas and natural gas departments. The growing development of natural gas long distance transmission has minimized the need for separate departments. The association will continue to sponsor activities of a specific interest to members of both manufactured gas or natural gas companies. The Manufacturers Section also is eliminated, as it has existed in name only since the Gas Appliance Manufacturers Association was formed.

A new section known as the General Management Section is established to deal with matters of a management nature other than accounting, operating, and sales promotional matters. Responsibility for a number of committees will be delegated by the board of directors to a section chairman and vice chairman of the new section.

Four principal and existing committees are provided for, namely: the General Nominating Committee, which will have nine members instead of six as heretofore; the Finance Committee; the Laboratories Managing Committee; and the Promotion, Advertising and Research (PAR) Committee. The Publicity and Advertising Committee is eliminated as a general committee, and will be designated as a special committee or a committee under the General Management Section.

The president, with the consent of the board of directors still may appoint other general or special committees of the association. Where any committee has to do with the raising and administering of substantial funds, such committee shall have the same status and kind of duties as the PAR Committee.

The executive board will comprise 35 elected members including the elected officers and the past president. The board of directors can invite chairmen to attend its meetings, so that the board may continue to have the advice of the heads of sections and committees charged with the handling of finances and funds of the association. Election and termination of memberships become the function of the board of directors. Rates of membership dues and special assessments now will be fixed by a concurring vote of a majority of the board of directors.

The Advisory Council will consist of 40 members appointed by the board of directors. Membership on the council no longer is limited to past members of the executive board.

The new Constitution and By-Laws represent the result of two and one-half years work on the part of a committee headed by Eskil I. Bjork, president of The Peoples Gas Light and Coke Company, Chicago. Suggestions and criticisms were requested and received from many executives in the industry, from the executive board and the executive committee, from chairmen of sections and committees.

Part of Interstate Line To Get Special Coating

The Gulf Coast Somastic Division of H. C. Price Company has announced that it will apply both Somastic and Hevicote protection to approximately 30 miles of Interstate Natural Gas Company's 16-in. line through southeastern Louisiana.

The Price company will coat the pipe for L. E. Farley, Inc., prime contractor on the Interstate project. The coated portion of the line, forming a vital link in Interstate's expansion program, will extend from the Intra-Coastal Canal near Berwick, Louisiana, northward across the Atchafalaya Basin towards Baton Rouge.

Due to delays in pipe deliveries occasioned by the steel strike, construction work on the new line will not start until early next year. The pipe is expected at Price's coating plant at Harvey, Louisiana, the first of January. The 16-in. OD pipe will be given a 9/16-in. coating of Somastic for corrosion protection and a jacket of Hevicote ranging from one inch to 1⅝ in. in thickness to meet negative buoyancy requirements.

Shell Transportation Film Is Ready for Distribution

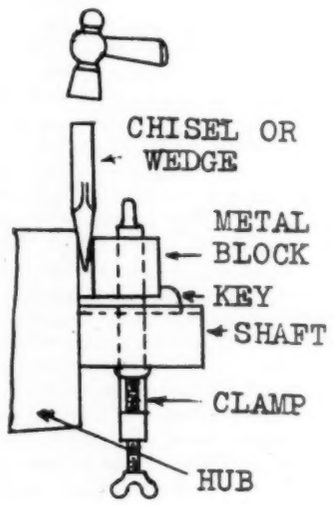
"Oil—The Invisible Traveler," a new color motion picture portraying all aspects of petroleum transportation, is ready for distribution, Shell Oil Company announces. The 20-minute, 16-mm sound movie is available free for showings. It was prepared especially for schools, social and fraternal groups, and civic organizations.

The new film is the fourth in a series entitled "This Is Oil," which Shell has produced to demonstrate the basic operations of the oil industry. The most recent movie tells how the oil industry performs the complicated task of moving more than 300,000,000 gal of petroleum a day from oil well to consumer. It traces by live action and animation the history of petroleum transportation, showing how the existing network of oil carriers—pipe lines, tankers, barges, tank cars, and trucks—evolved from the barrel, which was the only practical container available to pioneer oil men.

To increase the effectiveness of the film as an educational aid, the company has developed a special teachers' manual and wall chart. These are sent with the movie to schools. Other groups may obtain the wall chart and manual by request.

"Oil—The Invisible Traveler" is the fifteenth movie to be added to Shell's film library. The company has thousands of prints in circulation, being shown to more than 10,000,000 persons a year. Aside from various phases of the oil business, they deal with several other subjects, such as the theory of flight, principles of hydraulics, and traffic safety. Shell solicits requests for its catalog listing all titles. Address: Shell Oil Company, Film Library, Room 4226, 50 West 50th Street, New York 20, New York.

How to Pull a Tight Key



Here is a simple kink that the writer has found useful for pulling tight keys. The drawing makes the operation practically self-evident. The metal block is shown thicker than necessary in order to illustrate the method more clearly. In fact it is better to use a thinner block than shown in order to lessen the overturning movement. Of course the exact arrangement as sketched need not always be strictly followed, there being a hundred and one variations of problems and as many solutions all of which may be based on the same principle as illustrated here. The main idea is to use a metal block, the width of which is sufficient to leave a gap into which a chisel is driven for loosening the key. Sometimes a metal wedge such as used for splitting logs comes in handy for this same purpose, as the reader can readily visualize without the necessity of any further explanation.—W. F. S.

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European Gas Men Making U. S. Study

Seven engineers and managers of the gas industry in France and the Saar are studying American gas production and transmission methods in a technical assistance project directly related to the Schuman Plan for pooling coal and steel resources of Western Europe.

The study trip in the United States, sponsored by the Mutual Security Agency under its productivity and technical assistance program, also is expected to aid in supplying industrial plants and home consumers of the Paris area with more and cheaper fuel gas.

The study, in which three of the team members are concentrating on long-distance, high-pressure gas pipe lines, is taking the team to New York and Rochester, New York, Columbus and Cleveland, Chicago, Memphis, St. Louis, Atlantic City, where they will attend the American Gas Association Convention, Pittsburgh, and Washington, D. C.

The leader of the team, Andre Amsler, is the chief engineer in charge of a pipe line network being laid in the northern and northeastern part of France. Most of the French coke ovens and steel plants are in this area.

The system will connect these plants with a main line of 12-in. diam into which they will feed their surplus coke oven and blast furnace gas, carrying the gas 220 miles to feed the Paris area.

By taking excess gas from the steel plants, the pipe line is expected to supply the Paris consumers, both industrial and residential, with cheaper gas than they are obtaining at present. The pipe line, due for completion next year, will be the largest and most modern in Europe.

Gaz de France, the nationalized French gas company developing this project, is coordinating its activities with the closely related French steel and coal industry in preparation for integration in the European Coal and Steel Community (Schuman Plan).

Other subjects of study in the United States on the part of the team, such as problems resulting from substitution of natural or petroleum gas for coal gas, gasification of petroleum fuels, modern control methods, and industrial uses of gas, also are related to the pipe line project.

A study also is under way in Europe to determine the possibility of linking the Lorraine gas pipe line network, which was tied into the Saar network in 1950, with Germany and Belgium. Such a network, linking much of Western Europe with a low-cost fuel transmission system, would be an important complement to the Coal and Steel Community.

The production of gas, which is essential to industry and to the standard of living of France, has increased sharply since World War II. The 1950 total production was 42 per cent over that of prewar 1938.

Besides Amsler, the gas team members now in the United States are Jean M. Bijard, assistant to the chief engineer, Gas Division, Ministry of Industry and Commerce, Paris; Antoine de Jerphanion, manager, industrial applications division, Andre Flurer, chief engineer, equipment division, and Hubert Gaudry, research engineer, Research Laboratory, all of Gaz de France, Paris; Marcel Malherbe, manager, gas division, Nord and Pas-de-Calais Coal Mines; and Robert G. Guillet, general manager, Saar-Ferngas Company, Saarbrucken, the Saar.

API to Discontinue Accounts Publication

The American Petroleum Institute announces it will discontinue the publication and sale of the "Uniform System of Accounts for Pipe Line Companies."

These regulations were first reprinted in 1943 under the auspices of the API Division of Transportation.

As a result of discussions with officials of the Interstate Commerce Commission, a plan was developed by which the Government Printing Office would print a pamphlet edition of the regulations using type already set-up for the Federal Register. This would provide copies at a greatly reduced cost and relieve the Institute from having to print and distribute the regulations.

Copies of the pamphlet are available from Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 20 cents each.

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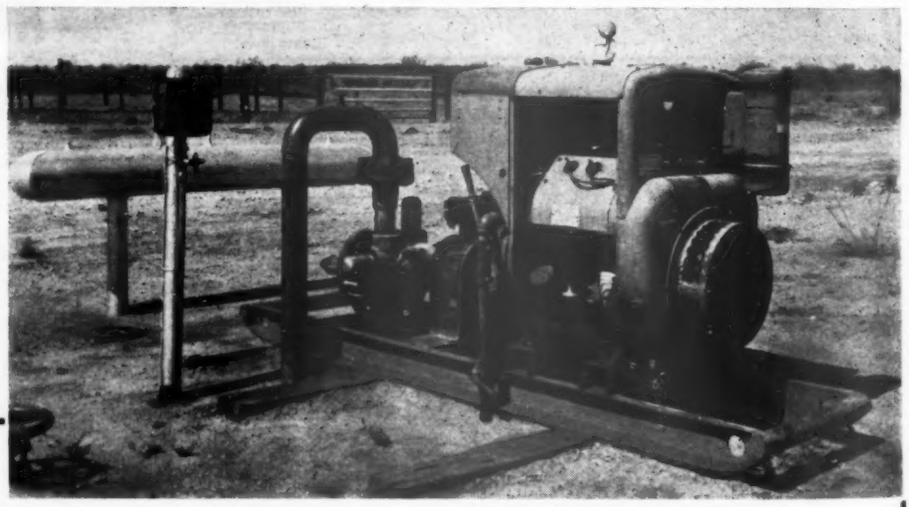

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Natural Gas Production Triples in 14 Years

Marketed production of natural gas in the United States almost tripled between 1936 and 1950 according to a summary of natural gas statistics for this period published by the U. S. Bureau of Mines. The publication, an information circular, was released by Under Secretary Vernon D. Northrop of the Department of the Interior.

Prepared by Donald S. Colby, commodity-industrial analyst, and Blanche E. Oppegard, statistical assistant, both of the bureau's Washington office, the publication presents the first summary of United States natural gas statistics published by the bureau since 1937, although such statistics are issued regularly on an annual basis. During this period, 1936-50, natural gas production increased from slightly over 2 trillion cubic feet to more than 6 trillion cubic feet. The circular attributes much of this rapid expansion to the increasing use of long-distance transmission lines.

Statistics on natural gas production were first collected for 1906, and a summary of statistics from 1906 to 1935 was incorporated in the bureau's *Minerals Yearbook* for 1937. The present circular consists of alphabetically arranged tables showing production and consumption figures for each state and one table showing figures for the United States as a whole. Summary from 1937 *Minerals Yearbook* is also included.

Texas was by far the greatest producer of natural gas in 1950, according to the circular, with a total marketed production of more than 3 trillion cubic feet. Next in line, producing nearly 832,000 million cubic feet, was Louisiana, followed by California and Oklahoma with totals of more than 558,000 and 482,000 million cubic feet, respectively.

Marketed production figures are:

	Millions of cubic feet	
	1936	*1950**
Alabama	---	2
Arkansas	8,500	48,047
California	320,406	558,398
Colorado	3,687	11,168
District of Columbia, Maryland, Virginia	---	419
Florida	---	8
Illinois	865	13,285
Indiana	2,241	956
Kansas	69,178	364,024
Kentucky	43,903	73,316
Louisiana	290,151	831,771
Michigan	7,167	11,250
Mississippi	11,821	114,153
Missouri	339	21
Montana	23,003	39,186
Nebraska	---	17
New York	12,431	3,336
New Mexico	33,928	212,909
Ohio	46,994	43,163
Oklahoma	280,481	482,360
Pennsylvania	110,362	91,137
Tennessee	84	132
Texas	734,561	3,126,402
West Virginia	138,076	189,980
Wyoming	29,322	62,062
North and South Dakota, Utah, Wisconsin and Washington	242	4,558

*1950 figure includes gas stored and lost in transmission.

States omitted had no production.

Realizing that an isolated series of statistics cannot reflect accurately the overall operations of the industry, the authors have designed their tables to show for each state the interpendent changes taking place in the various sectors surveyed.

The tables show number of producing gas wells, production from gas wells, and oil wells, gross and marketed production, underground storage, interstate shipments, and the amount of gas treated at natural gasoline plants.

"Natural Gas Statistics, 1936-50" may be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Penna.

Supervisory Changes Made By H. C. Price Company

Several major changes in the supervision of H. C. Price Company's construction operations have been announced by Harold C. Price, president.

Robert K. Shivel, veteran spread superintendent has been named superintendent of the pipe line division. Succeeding Shivel as superintendent of Spread Two is Robert L. Ezell, who has held the position of welding foreman in the Price organization for many years. At the same time, Roy E. Burgess has been made administrative manager, and Harold C. Price, Jr., has been named administrative assistant of the pipe line division.

Other key personnel in the pipe line division include superintendent G. A. Reutzel, Spread One; Clarence Shivel, Spread Three, and Charlie Ice, Spread Four.

Shivel began pipelining in 1925 and joined the Price company in 1930 as a welder. He has participated in pipe line projects throughout the United States, South America, Canada, and Alaska. Shivel's new assignment follows a successful career as welding foreman and spread superintendent. He resides in Tulsa, Oklahoma.

Ezell, a native of Texas, also joined the Price organization in 1930 as a welder. He has served as a welding foreman for a number of years, and his promotion gives Price an experienced and highly regarded pipeliner for this assignment.

Burgess has served as assistant purchasing agent, field office manager, and administrative assistant in the pipe line division during the eight years he has been with the Price organization.

Harold C. Price, Jr., started to work for the company following his graduation from the University of Oklahoma. After a tour of duty in the field, Harold was named assistant secretary.

How to Make Emergency Bushings

When standard bushings are unavailable and you are in urgent need of one or more such bushings, there usually is a way in which to make an emergency bushing that will serve the purpose. This is one of the advantages of mechanical drive.

Babbitt and lead often lend themselves to an occasion of this kind better than anything else. Nearly every mechanic knows how to babbitt a bearing. At least he *should* know.

To apply a babbitt or lead bushing, all that is necessary is to support the pulley in any convenient way so that it is in its correct position around the shaft. That is, it must be concentric. Then by means of putty, or any other suitable material, build dams around the openings and arrange the mould so that the metal can be poured. The method is so obvious that detailed explanation is unnecessary. Then pour the metal about as indicated in Fig. 1.

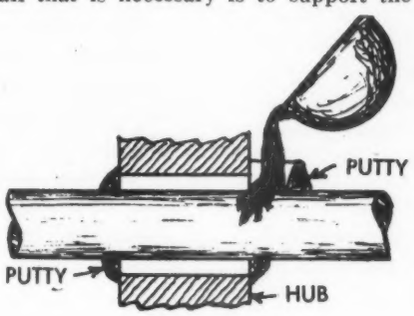


FIG. 1.

For split pulleys, if it so happens that the bushing must be exactly ⅛ in. thick, or ¼ in., and if you have in stock some round iron rods ⅛ or ¼ in. in diam, cut the rods to a length slightly greater than the length of the pulley hub. Then use the rods for bushings placed side by side to fill the entire space between the shaft and pulley as shown in Fig. 2.

Square stock is better than round stock for this purpose because the round pieces will act like rollers in a roller bearing if the pulley is not bolted up sufficiently tight to prevent such motion. For this reason rough round pieces are better than smooth ones. Use square or rectangular stock in preference to the round if the former is available.

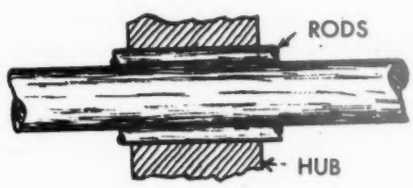
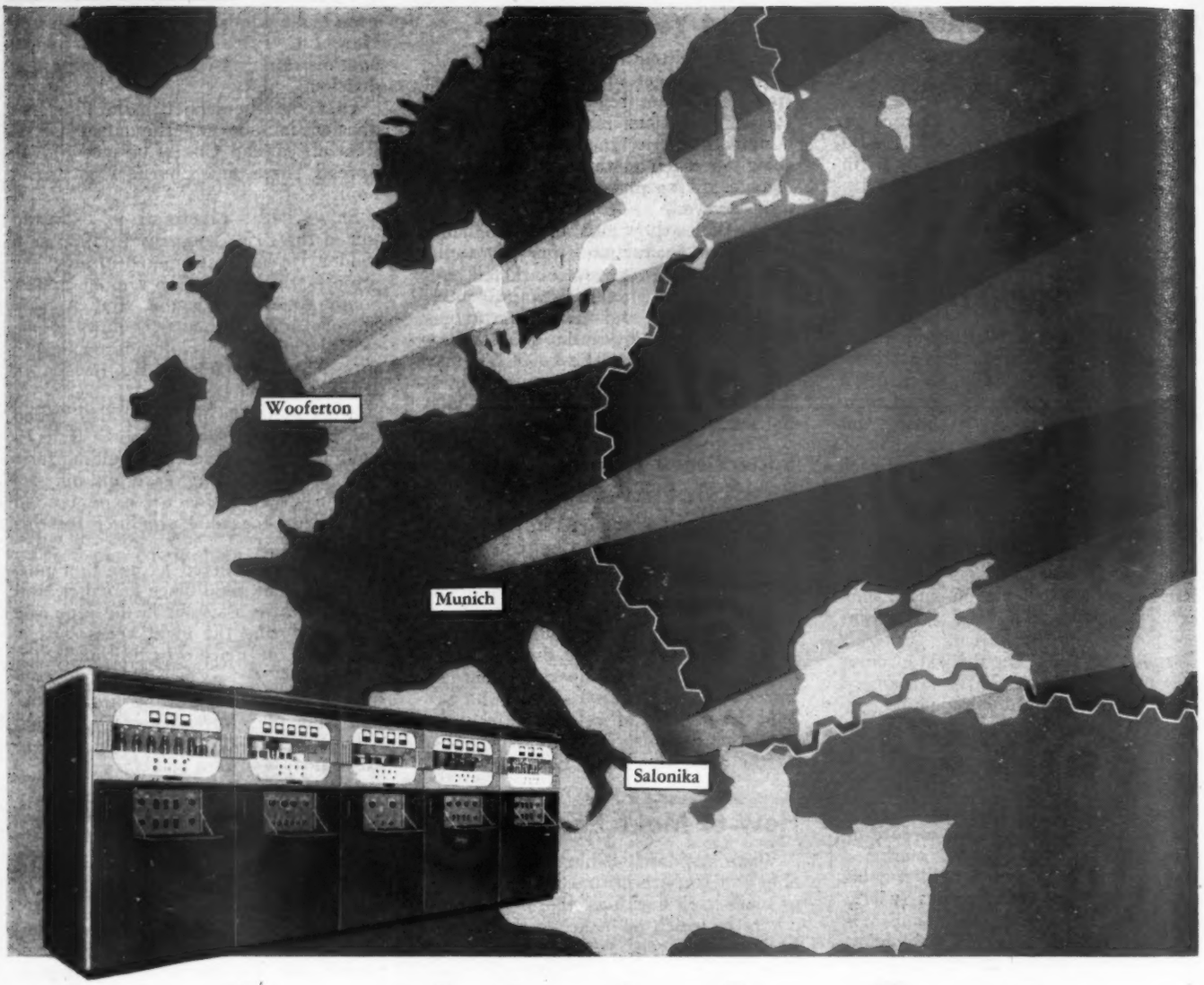


FIG. 2.

Sometimes the quickest way is to use strips of hardwood laid side by side around the interior of the pulley in the manner explained above for the rods. Wood is more easily reduced to the proper size than metal. Where there is ample contact surface between the pulley and shaft wood generally serves the purpose just as well as metal.



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Gas Company Revenues Near $2 Billion

Gas operating revenues of 140 natural gas companies filing annual reports with the Federal Power Commission totaled $1,923,336,000 for the year 1951. Sales of natural gas by the companies amounted to 6.92 trillion cubic feet.

A high proportion of the operating income of certain of the reporting natural gas companies is derived from other than natural gas operations. In order that developments in the natural gas industry may be observed unaffected by other utility operations, these companies have been excluded from the comparative 1951-1950 data shown in the statements summarized from the field reports and referred to below.

Sale of natural gas and revenues from such sales reported by the predominantly natural gas companies for 1951 amounted to 6.45 trillion cubic feet and $1,588,622,000, respectively, representing increases of 17.7 per cent in sales and 23.5 per cent in revenues, over sales of 5.48 trillion cubic feet and revenues of $1,286,837,000 in 1950. Service was supplied to an average of 6,694,000 customers during 1951 compared to an average of 6,137,000 during 1950, or an increase of 9.1 per cent.

Gas operating revenue reductions including charges for operations and maintenance and provision for depreciation and taxes amounted to $1,398,271,000 for the year and in relation to revenues increased slightly from 83.7 cents per revenue dollar in 1950 to 84.4 cents in 1951. During 1951, 63.9 cents of the revenue dollar went for operating expenses, including the cost of purchased gas, 8 cents for depreciation, 7.8 cents for federal taxes on income, and 4.7 cents for other federal, and state and local taxes.

Gas utility operating income for 1951 amounted to $259,317,000 and was equivalent to 6.3 per cent of the average net gas investment for the year. For 1950 gas utility operating income was $218,671,000 and the comparable rate 6.6 per cent.

Gross income of the companies, including income of $1,336,000 from utility operations other than gas and $11,739,000 non-operating income, amounted to $272,392,000 for 1951. Income deductions aggregated $70,138,000 for the year. Interest on long-term debt, amounting to $65,728,000 for the year, was earned 4.1 times.

Net income of the companies for 1951 amounted to $202,254,000, representing an increase of 9.9 per cent over the $183,974,000 reported for 1950.

Dividend appropriations during 1951 totaled $136,863,000 of which $9,627,000 went to holders of preferred stock and $127,236,000 to common stockholders. In 1950 appropriations for preferred and common dividends were $6,191,000 and $123,377,000, respectively.

Book investment in gas utility plant by the predominantly gas companies aggregated $5,361,293,000 on December 31, 1951, an increase of more than one billion dollars, or 22.9 per cent over the $4,524,970,000 reported a year earlier. Reserves for depreciation amounted to $1,150,484,000 at the end of 1951 compared to $1,027,395,000 at the end of 1950.

Reflecting the increased plant investment, outstanding securities of the companies, including equity and debt, increased from $3,255,657,000, at the end of 1950 to $3,946,990,000 at the end of 1951.

The increase in outstanding equity securities amounted to $127,648,000 and in debt securities to $563,685,000. Combined capital and earned surplus increased $69,996,000 during the year. At the end of the year equity and debt securities outstanding totaled $1,311,022,000 and $2,635,968,000, respectively, and combined capital and earned surplus, $521,560,000.

PG&E Now Building New Gas Pipe Line

A three-part, $872,204 pipe line project to provide the North Bay with additional West Rio Vista field natural gas is making rapid progress.

The now-building Pacific Gas and Electric Company pipe line, 16 in. in diam, originates at a major PG&E line-junction 6 miles south of Napa and runs due west 19 miles to Old Adobe, near Petaluma, California.

Arthur D. Church, PG&E North Bay Division manager, said that his company completed an initial 5-mile section from Shellville east to Duhig Road last fall, and now has begun work on another stretch, 6 miles long, from Duhig Road east to the Napa junction, transmission station.

Santa Rosa, San Rafael, Healdsburg, Sonoma Valley (including part of Napa) and Marin peninsula are the areas in PG&E's North Bay Division that normally receive West Rio Vista field natural gas.

"There are two principal reasons why we must build this 16-in. line," Church said. "First, the demand for gas in the North Bay area continues to increase about 10 per cent annually, and second, the pressure in Rio Vista field continues to diminish gradually each year." Rio Vista Field, however, is still the largest natural gas field in California, he added.

The westernmost leg of the line, an 8-mile section from Shellville to Old Adobe, probably will not be built until next year, the utility manager said.

"We delivered 78,025,000 cu ft of gas January 3, our peak day of last winter, to the North Bay Division as a whole. Ten years ago our 24-hr period peak was only 36,875,000. Our customer growth in the division is similar. Fifteen years ago we had 33,070 gas users, today there are 81,664," Church explained.

This upward trend in gas usage and customer growth is expected to continue unabated into the foreseeable future, he said.

The new line roughly parallels an already-existing 12-in. line, laid in 1930, from the Napa line-junction to Petaluma.

Marshall E. Parker

Cormit Engineering Company Is Formed

Marshall E. Parker, who has been engaged in the practice of corrosion engineering as a consultant, has formed the Cormit Engineering Company to broaden the scope of his activities. In addition to consulting, surveys, and design, the new company is prepared to make complete installations of cathodic protection systems on oil and gas pipe lines, tank farms, steel piling, and wharves, and on other metallic structures exposed to the corrosive action of soil or water. The company has offices in the M & M Building, No. 1 Main Street, Houston, Texas, and, according to Parker, operates on the conviction that corrosion mitigation is an engineering problem, and can yield only to an approach based on sound engineering principles.

MURPHY Switch Model -45 for Pipeline Pumps shuts down pump *automatically* when

- **SURFACE LINE BREAKS**
- **OIL SUPPLY FAILS**
- **DANGEROUS OVERPRESSURES THREATEN**

This model is also widely used as safety shut down on gas compressor plants and pipeline pumps.

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165,000 hours of service completed by 28 Alco Diesels at 98½% availability

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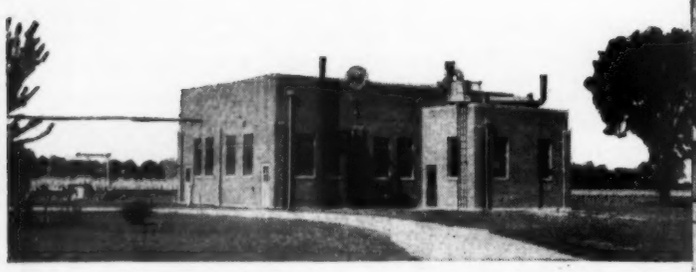

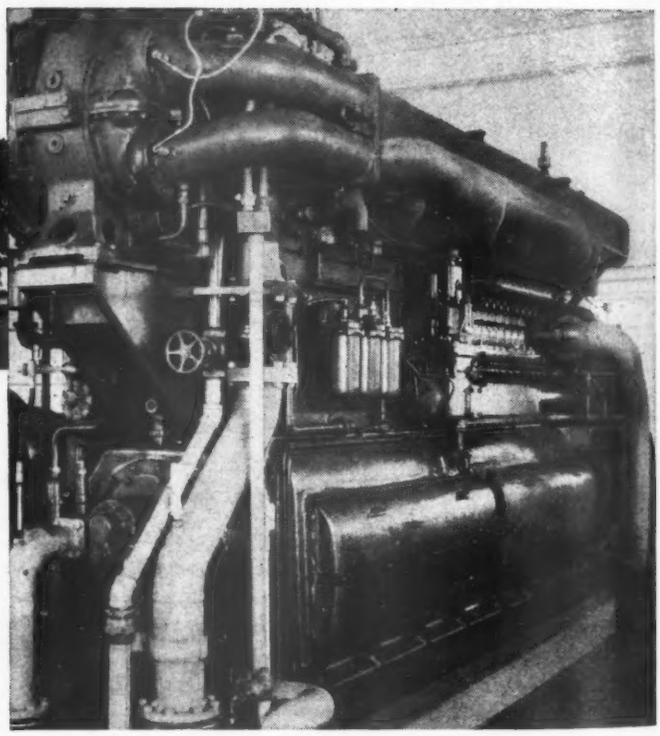

Twenty-two years ago, Gulf Refining Company installed 28 Alco Diesel Engines on its new, 700-mile Tulsa-to-Spencerville Junction pipeline. Today, those 28 Alco Diesels have completed more than 165,000 hours of service and are operating at 98½% availability. And since 1941, when the output of the line was greatly increased, they have been in actual service an average of 97% of the time.

Pumping station superintendents throughout the United States and Canada specify Alco Standardized Diesels because of this kind of *proved* dependability——and because of these economy features:

- **Compactness**—for lower construction costs
- **Higher Engine Efficiency**—for lower fuel costs
- **Medium Speed**—for lower auxiliary equipment costs
- **Flexible Power Range**—for lower expansion costs

For the complete story on Alco Diesel Engines, contact your nearest American Locomotive Company Sales Office. You will find them in New York, Beaumont, Chicago, Cleveland, Houston, Kansas City, San Francisco, Schenectady and St. Louis.

ALCO DIESELS

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AMERICAN LOCOMOTIVE COMPANY

Gas Pipe Line to Make Interconnection

The Federal Power Commission has issued a certificate to Transcontinental Gas Pipe Line Corporation, of Houston, Texas, and Texas Eastern Transmission Corporation, of Shreveport, Louisiana, authorizing the operation of an interconnection near Philadelphia, Pennsylvania, of the natural gas pipe line facilities of the two companies.

Temporary authorization for the construction and operation of the facilities was granted by the FPC last May 15. The facilities are used for deliveries by Transcontinental to Texas Eastern, which in turn is delivering for the account of Transcontinental up to 60,000,000 cu ft a day to The East Ohio Gas Company, New York State Natural Gas Corporation, and The Peoples Natural Gas Company; up to 10,000,000 cu ft to United Natural Gas Company, and up to 600,000 cu ft to Indiana Gas and Water Company.

The gas sold by Transcontinental at 28 cents per 1000 cu ft and Texas Eastern is making no charge under the agreements. The agreements provide for the sale of the gas by Transcontinental for underground storage purposes in order that the purchasers may meet their anticipated peak-day demands during the 1952-1953 winter heating season. The companies plan to continue the service until November 30, 1952, expiration date of the presently accepted service agreements.

TGT and Northeastern Complete Programs

The Tennessee Gas Transmission Company has announced the completion of both the presently authorized pipe line facilities of its New England subsidiary, Northeastern Gas Transmission Company, and its own major 1952 construction program along its 2000-mile Texas to Massachusetts pipe line system, longest in the nation.

Gardiner Symonds, president of both companies, said Northeastern recently completed all its 515-mile pipe line system in Massachusetts, Connecticut, and New Hampshire and is now serving all its authorized customers. These include 35 New England gas utility systems, which in turn are serving hundreds of thousands of homes, commercial firms, and industries in the three states.

Meanwhile, the system capacity of Tennessee Gas, operator of one of the nation's major natural gas transmission systems, has been increased to 1,350,000,000 cu ft per day as finishing touches are put on a big 1952 construction program.

That program included the laying of 528 miles of loop pipe line parallel to its existing system, building four new compressor stations in Ohio, Pennsylvania, and New York, and enlarging 16 of the existing compressor stations.

Still more growth for the company, which has expanded every year since its first full year of operation in 1945, has been authorized by the Federal Power Commission and will go forward in 1953 and subsequent years. The FPC has authorized expansion that will increase daily delivery capacity to 1,515,000,000 cu ft., together with underground storage facilities to be constructed near Hebron, Pennsylvania, which will increase peak day delivery capacity to 1,715,000,000 cu ft. The authorized construction includes 591 miles of pipe line parallel to the existing system, a new 304-mile pipe line from the existing system near Mercer, Pennsylvania, through the Hebron field to the existing system near Utica, New York, and 165,000 additional horsepower to be installed at new and existing compressor stations.

Completion of Northeastern Gas' system in New England finished a job begun in the spring of 1951. The work was pushed and in September, 1951, the first natural gas service in New England's history was begun. By the end of the year, Northeastern was delivering natural gas to the distributing systems of a dozen Massachusetts cities and towns.

Northeastern's 1952 construction included finishing the pipe line across Massachusetts to the seacoast at Gloucester, building a 100-mile spur line south across Connecticut, and a 40-mile line north into New Hampshire near Concord. Service was given 22 additional gas utilities in the three states this year.

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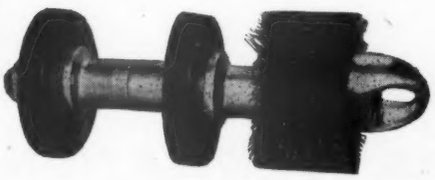
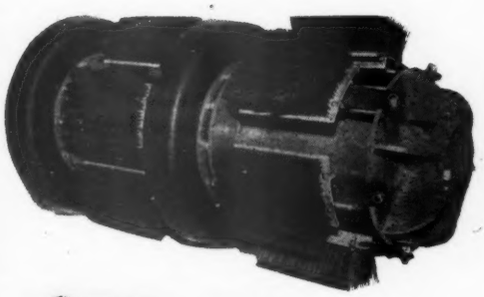


Type JR Pig 2" to 5" sizes. Economical and Rugged.



Type GP-4 Pig 16" to 30" sizes.

Similar design for 10" to 14" sizes.

Brushes expanded by arched springs.

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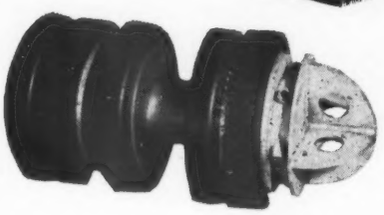

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Pipe Line Personals

Everett D. Bivens, who has been vice president and general manager of the Charleston Group Companies, has been named vice president and general manager of the Columbus Group Companies of the Columbia Gas System. Bivens assumes the post vacated by **Allan W. Lundstrum,** who has been made president of the Ohio Fuel Gas Company, succeeding **William N. Grinstead** who died in July. In the Charleston Group, the duties performed by Bivens are distributed among other officers of the companies. **John W. Partridge,** president, takes over the work of the general manager as well. A new operating committee has been created, whose members are **F. C. Davis, J. J. Martin, J. W. Kelley,** and **E. C. Stump,** all vice presidents.

George Studebaker, superintendent at Liberal, Kansas, has been transferred to Sunray as compressor station superintendent by Northern Natural Gas Company. **Fred Hammons,** formerly assistant superintendent at Clifton, has assumed the duties of superintendent at Liberal. **Gene Funnell,** who has been assistant superintendent at Hugoton, has been moved to Clifton in the same capacity. **Avis Waldroop,** master mechanic at Liberal, has been made assistant superintendent at Hugoton.

Bennie G. Pierce

Bennie G. Pierce, safety director for H. C. Price Company, Bartlesville, Oklahoma, led a discussion on "Safety in Pipeline Construction" during the 40th annual congress and exposition of the National Safety Council in Chicago. The meeting conducted by Pierce marked the first time that pipe line safety has been included on the agenda at the Safety Council's national meeting.

Participating in the panel discussion with Pierce were **Richard A. Gump,** executive secretary, Pipe Line Contractors Association, Dallas, Texas; **S. H. Downey,** safety director, Southern Natural Gas Company, Birmingham, Alabama; **H. C. Markel,** safety director, Phillips Petroleum Company, Bartlesville, Oklahoma, and **Ray M. Garrigus,** safety engineer, Tennessee Gas Transmission Company, Houston, Texas.

G. E. Kendrick has been promoted from assistant superintendent of the Jal division to superintendent of that area by El Paso Natural Gas Company. **Estin Scearce,** formerly superintendent of the Jal division, has been made operating manager of the Permian division. Scearce, together with **W. H. Miller, R. W. Harris,** and **J. F. Eichelmann** make up the newly created operating department in the home office in El Paso.

Howard Boyd has been elected vice president of the company and will make his headquarters in Houston, Texas. **D. H. Tucker** was recently elected a director of the company, and he also has his office in Houston.

W. H. Miller has been promoted from superintendent of the mainline compressor department to operating manager of the Southern division.

T. H. Pofahl has been promoted from assistant superintendent of the mainline compressor department to compressor superintendent of the Southern division.

C. L. Moore has been promoted from assistant chief engineer to executive engineer and is now in direct charge of the company's engineering department.

E. W. Woody superintendent of the Tucson district, has been made pipe line superintendent of the Southern division. His headquarters are in El Paso.

W. O. Angus has been elevated to assistant safety director of the company. He formerly was safety engineer.

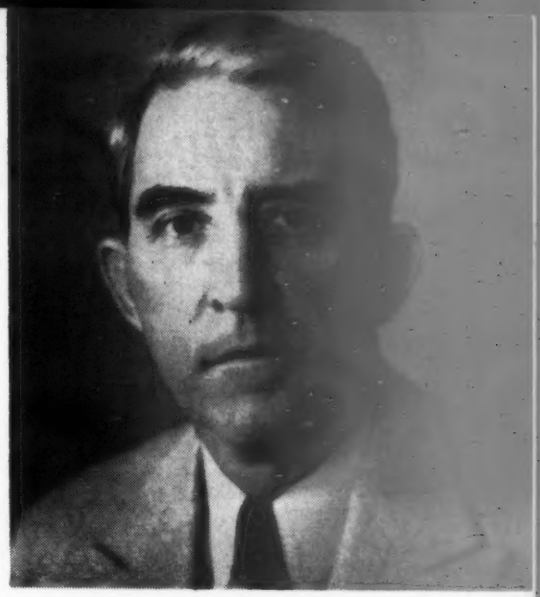
J. F. Eichelmann, chief engineer, has been made a member of the operating department. He will coordinate engineering matters among the engineering department and the operating and construction departments.

R. W. Harris has recently been promoted from San Juan division superintendent to operating manager of the San Juan division. He also is in charge of the pipe line construction department.

J. M. Stricklin, formerly transmission superintendent, has been promoted to superintendent of the San Juan division.

J. D. Griffis, former maintenance man in the Shreveport, Louisiana, district for United States Gas Pipe Line Company, has been made machinist at the Latex station, Texas, in the same district. **J. O. Munnerlyn,** first engineer in the Houston, Texas, district, has been transferred to Latex station.

O. W. Heyden, since 1941 assistant chief engineer of Shell Pipe Line Corporation, has been advanced to acting chief engineer. A graduate of Tulane University with degrees in mechanical and electrical engineering, Heyden joined Shell Oil Company at the Norco, Louisiana, refinery in 1931. He spent 10 years there, as assistant power engineer, senior technical assistant, assistant chief engineer, and acting chief engineer, prior to joining Shell Pipe Line at Houston, Texas.



Wallace R. Finney

Wallace R. Finney, retiring pipe line advisor to Standard Oil Company (New Jersey) was honored by his fellow oilmen today "for his outstanding contribution to petroleum industry transportation." Finney retired October 1, bringing to an end an active career in oil that began in 1914.

The veteran oilman was honored at a luncheon held at the University Club in New York City under the sponsorship of P. C. Spencer, president, Sinclair Oil Corporation, and A. W. Peake, president, Standard Oil Company (Indiana). Spencer and Peake both are ex-Wyoming-ites who wished to salute another ex-Wyomingite, Finney, on the occasion of his retirement.

Finney began his oil career in his native state of California on a pipe line gang. Beginning in 1918, he spent 11 years in Wyoming designing, constructing, and operating gasoline plants and pipe line facilities.

During his industry association, Finney has headed, been a director of or an advisor to numerous pipe line construction and operating organizations both in this country and overseas. He joined the Jersey Company in 1932 and had filled the office of Pipe Line Advisor since it was created in 1944. He assisted in planning for the Trans-Arabian and other Middle East pipe lines, and during World War II he headed the industry committee that supervised the design and construction of the Big and Little Inch emergency pipe lines.

Don Sorenson recently assumed the post of meteorologist in Northern Natural Gas Company's dispatching department at Omaha, Nebraska. He has been employed by Peoples Division of the company at Spencer, Iowa, as utilityman.

Byron Francis, assistant to **Joe Innis,** vice president in charge of operations for Northern Natural Gas Company, is now serving in Washington with the Petroleum Administration for Defense. He will be special assistant to the director of the Gas Facilities Division, which handles applications for controlled materials to be used for construction. He will be on the new job for about a year.

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Pipe Line Personals

Roy Knoettgen, assistant compressor station superintendent at Bushton, Kansas, for Northern Natural Gas Company, has been transferred to Sublette as assistant compressor station superintendent. **Merlin Esslinger,** assistant compressor station superintendent at Sublette, moves to Mullinsville in the same capacity. **Dale Kullbom,** assistant compressor station superintendent at Mullinsville, is now holding down the same post at Bushton. **Theodore Pounds,** master mechanic at Bushton, has been moved to Holcomb as master mechanic. **James Hinzman,** master mechanic at Holcomb, now occupies that post at Bushton. **Lloyd Packer,** shift engineer at Bushton, is now shift engineer at Beaver. **Dick Smith,** shift engineer at Beaver has been made shift engineer at Bushton. **Alfred Urbanek,** assistant shift engineer at Bushton, is now at Oakland in the same capacity. **James Barnes** has been moved from Oakland to Bushton as assistant shift engineer. **James Burnett,** shift engineer, Liberal, is now shift engineer at McConnell. **Alvie Mills,** shift engineer, McConnell, moved to Liberal in the same capacity.

Two TGT Vice Presidents Go With Other Companies

After long service with Tennessee Gas Transmission Company, during which they gained valuable executive experience in natural gas and related fields, two vice presidents have recently accepted positions with other firms.

They are W. E. Mueller, now executive vice president of the Colorado Interstate Gas Company of Colorado Springs and W. C. Norman, now a general partner in the New York capital investment firm of Lambert and Company. Both joined TGT during its formative days in 1943 and grew with the company.

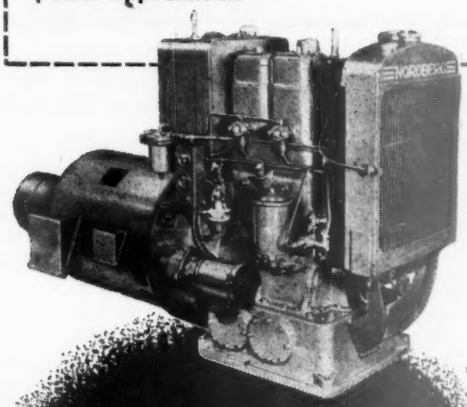
Mueller was a senior vice president and director of Tennessee Gas and also served as president and director of the Tennessee Gas Building Corporation and as director of the Tennessee Production Company, TGT affiliate companies.

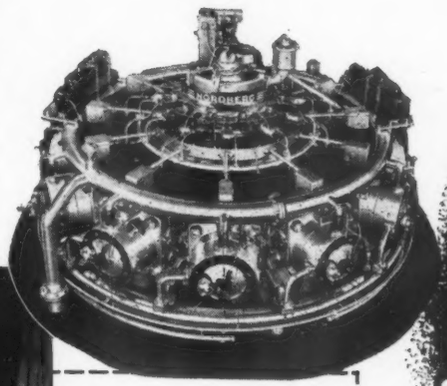
In addition to their other duties, TGT Vice President and Controller R. L. McVey has assumed Mueller's Tennessee Gas responsibilities and TGT Vice President Carl Myers has taken over Mueller's building corporation duties. Vice President C. A. Lingo, who heads the Land Departments of both Tennessee Gas and the Tennessee Production Company, was named a director of the Production Company to fill the board vacancy.

Norman had held the dual position of vice president of TGT and president of TGT's New England subsidiary, Northeastern Gas Transmission Company. After Norman's departure, TGT's President Gardiner Symonds, who was also chairman of the board of Northeastern, became Northeastern's president as well as board chairman and N. W. Freeman became executive vice president of Northeastern in addition to his other duties as TGT vice president in charge of sales. He is supervising Northeastern's operations from Houston.

The Nordberg **SUPAIRTHERMAL** Engine, the latest development in the Diesel field, is available in a complete range of 4-cycle types for all applications, in sizes from 535 H.P. upward, including Diesel, Duafuel, or spark fired gas operation.

Nordberg "Packaged" 4-cycle Diesel Power Units—from 10 to 45 H.P., 6 to 30 K.W., for generating electricity, pumping, and straight power applications.





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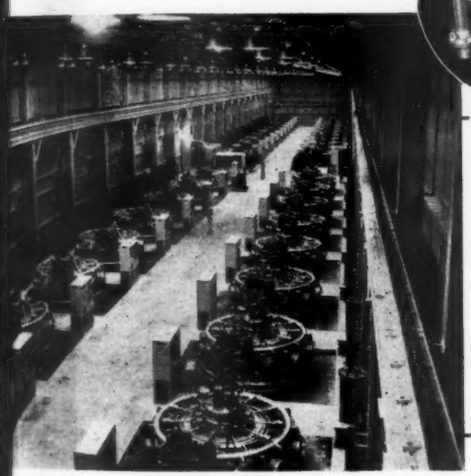
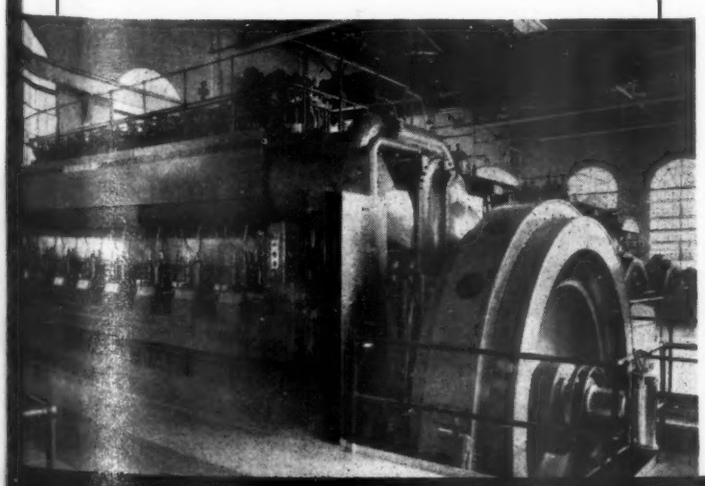


Nordberg 2-cycle Radial engines develop 2125 H.P. or 1500 K.W. at 400 R.P.M. Available as an oil burning Diesel, as a natural gas engine, and as a Duafuel engine.

Nordberg 2-cycle Duafuel engines are built in a wide range of sizes from 1570 H.P. upward—all of which burn oil, gas, or any combination of both—and are instantaneously convertible from one fuel to another, under full load.



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PIPE LINE PROJECTS

Westcoast Receives Final Approval for Gas Line

Final approval has been given the Westcoast Transmission Company, Ltd., by the Board of Transport Commissioners for Canada, to construct a natural gas pipe line from the Pouce Coupe area of Alberta to Vancouver, British Columbia, with a branch from Abbotsford to a point on the International Boundary at Huntingdon. Conditional approval was given last June. At that time, however, the Board of Transport Commissioners stated it first wished to procure, by means of its own engineering staff, and the geological staff made available to them by the Department of Mines and Technical Surveys, an estimate of gas reserves in the Peace River district, and possibly other districts. The study by the Department of Mines and Technical Surveys was made by Dr. G. S. Hume, director general of scientific surveys, and A. Ignatieff, one of the senior engineers of the department. Their findings have now been made known by the Hon. Mr. Justice John D. Kearney, chief commissioner of the Board of Transport Commissioners.

The report concludes that the proved and probable reserves of natural gas *in situ* in the Peace River area amount to 2506 billion cubic feet, of which 1585 billion cubic feet are in British Columbia and 921 billion cubic feet in Alberta. The quantity of gas available to Westcoast will depend on the production characteristics of each reservoir from which the gas is drawn, it is pointed out by Chief Commissioner Kearney. It is considered at this stage of development, however, that a reasonable overall estimate of the recoverable gas is 75 per cent of the gas *in situ*. After considering all the facts, the Board of Transport Commissioners concluded that the Hume-Ignatieff estimate of reserves was a reasonable one and sufficiently great to warrant granting permission to construct the line.

"It is significant," said the judgment written by Chief Commissioner Kearney, "that when Westcoast first applied to this Board for leave to construct a pipe line it was to reserves in Alberta that the company looked for its supply of gas, and the company at that time lacked the necessary permit to remove gas from that province. The situation has changed materially since that date in several respects. The permit has now been obtained from the Alberta authorities for removal of gas from the Peace River area. In addition, the company will be able to draw on the gas reserves that have been discovered in the British Columbia portion of the Peace River area. The estimated reserve in the latter portion is even greater than in the Alberta portion, and as pointed out in the report the most impressive results in the whole Peace River area are being furnished by the drilling in the St. John area. The reserve presently indicated there is large, yet the present results have all been achieved since March, 1952. This is a striking indication of how rapidly gas reserves in new fields in Alberta and British Columbia are being discovered and enlarged.

"Moreover, in British Columbia there are no provincial restrictions on the export of gas, nor any restrictions on the taking of gas from any area of the province nor an equivalent of The Petroleum and Natural Gas Conservation Board of Alberta.

"The government of British Columbia, through its counsel, stated to the Board at the June hearing, that great economic benefits would accrue to British Columbia by development of its oil and gas reserves, and that it strongly supported the Westcoast application and urged the immediate construction of the line. It is also evident that the government has the support of the legislature of British Columbia in respect of this policy because the legislature passed an unanimous resolution urging the adoption of the route through the Pine Pass, which is proposed by Westcoast, to take gas from the Peace River area."

Thus Westcoast can now draw on reserves in British Columbia as well as in Alberta.

The permit granted to Westcoast to remove gas from Alberta is for a term of 22 years and the amount of gas authorized to be removed during the first five years is 210 billion standard cubic feet. This represented the amount of deliverable gas that The Petroleum and Natural Gas Conservation Board found to be surplus to the requirements of Alberta as at December 31, 1951; however, at any time Westcoast can apply under Section 10 of the Gas Resources Preservation Act for an increase in this initial allotment.

In authorizing the construction of the Westcoast line, it was stipulated that construction be completed before October 31, 1955.

Products Line to Be Built in Washington

Plans for construction of a 140-mile petroleum products pipe line in the state of Washington are announced by Standard Oil Company of California and its subsidiary, Salt Lake Pipe Line Company.

The pipe line, of 8-in. diam, will be built from Pasco, on the Columbia River, to Spokane.

In making the announcement, Standard President T. S. Peterson said that the line's initial capacity of 12,000 bbl a day will enable his company to provide better service and assure supply of vital petroleum products to customers in Washington's Inland Empire.

Estimated cost of construction, which will include a pumping station at Pasco, is about $4,500,000.

C. E. Finney, Jr., president of the pipe line company, said that actual construction work on the line will begin as soon as right-of-way clearances can be obtained, and delivery of pipe is assured. It is expected, he said, that the line will be completed and in full operation by the middle of next year.

Products to be shipped through the proposed new line will be brought to Pasco by barge up the Columbia River, and through a pipe line completed from Salt Lake City to Pasco two years ago. This line, built and operated by Salt Lake Pipe Line Company, carries products manufactured in a newly constructed refinery at Salt Lake City, and is part of an integrated transportation system developed by Standard to provide greater assurance of supply to its customers.

MidSouth Authorized To Construct Gas Line

MidSouth Gas Company, of Little Rock, Arkansas, has been authorized by the Federal Power Commission to construct a total of about 191 miles of natural gas pipe line and to acquire an existing 38-mile line, all in Arkansas.

The 191 miles of lateral pipe lines will be used to supply 25 communities in Arkansas with natural gas. The 38-mile pipe line will be acquired from Arkansas Power and Light Company, of Pine Bluff, Arkansas. This line extends from a connection with the facilities of Texas Gas Transmission Corporation, near Helena, Arkansas, to Arkansas Power's Hamilton Moses Steam Electric Generating Station near Palestine, Arkansas. Total estimated cost of the acquisition and construction is $4,524,200.

Twenty of the Arkansas communities will be supplied with natural gas that MidSouth will obtain from Texas Gas, and the remaining five communities will be served with gas procured by MidSouth from Texas Eastern Transmission Corporation. In addition, MidSouth will transport gas received from Texas Gas through the line to be acquired from Arkansas Power, from Helena to the Arkansas Power's Hamilton Moses power plant.

The order requires MidSouth to begin construction, and consummate the acquisition, within two months, and to complete construction within 12 months.

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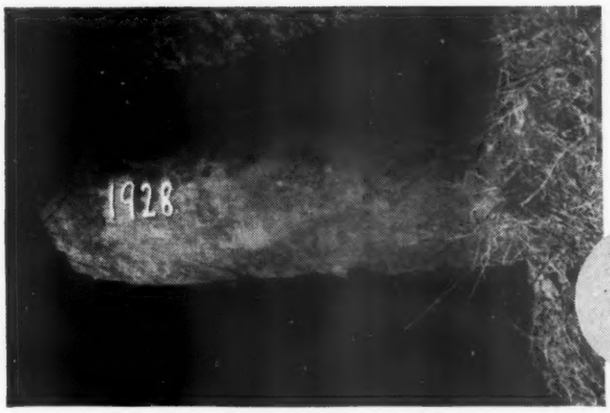

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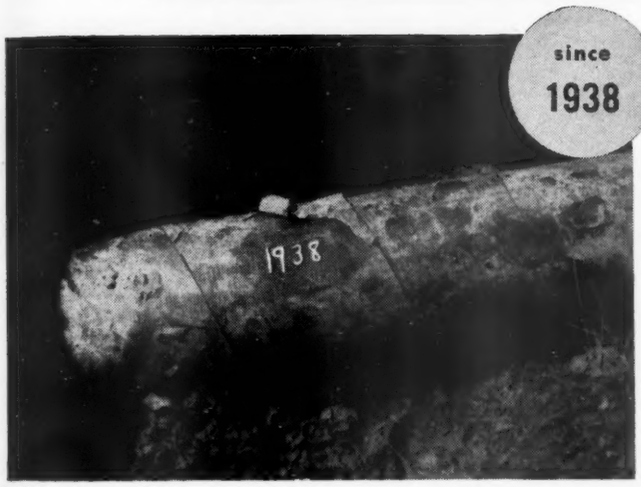
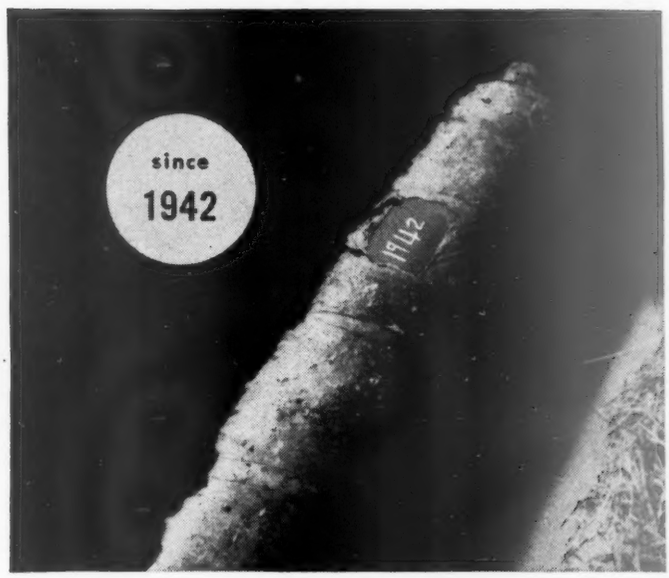


since 1938



since 1942

Here are three typical examples of NO-OX-ID protection with service records ranging from 10 to 25 years. These unretouched photographs show the coating turned back and reveal the excellent condition of the pipe underneath.

Each of these bell-holes show pipe buried in low resistance, poorly drained, clay soils. The NO-OX-ID application in each case was a cold applied and wrapped combination. No cathodic protection was used on any of these lines.

Specify NO-OX-ID combination on your next job. You can't buy better protection for underground pipe.

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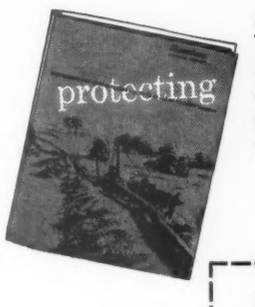

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A copy of "Preventing Corrosion on Underground Pipe Lines with NO-OX-ID and NO-OX-IDized Wrappers" will be sent on request.

Dearborn Chemical Company, Dept. PE
Merchandise Mart Plaza, Chicago 54, Illinois.

( ) Please send catalog "Preventing Corrosion"
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THE ORIGINAL RUST PREVENTIVE

Pipe Line Projects

East Tennessee Gas Proceedings Reopened

A Federal Power Commission presiding examiner has filed a decision, subject to review by the commission, reopening the proceedings on an application by East Tennessee Natural Gas Company, of Knoxville, Tennessee, to construct natural gas pipe line facilities in Tennessee, for additional evidence on financing, markets, and other matters.

The decision, filed by Examiner Marvin Farrington, says that the evidence introduced by East Tennessee shows no present ability or source of funds to finance the project. Farrington said that the evidence merely supports the proposition that once certain conditions are met by East Tennessee, the funds to finance the project may become available upon terms and conditions not yet known.

East Tennessee's application involves the proposed construction of an extension of its existing system, consisting of about 100 miles of 16-in. pipe from a connection near Knoxville to a point in the Kingsport, Tennessee, area, and approximately 63½ miles of various sized lateral lines, together with metering and measuring equipment to render wholesale and direct natural gas service. Estimated cost of the project is $5,784,608.

The company proposes to finance the project through the issuance of $4,500,000 in first mortgage bonds and $1,300,000 in bank loans; however, no evidence was presented to show that firm commitments had been made, and the company taking the position that a definite plan of financing cannot be presented until a pending application, in which it is seeking a rate increase, has been determined by the FPC.

Examiner Farrington also said that additional evidence should be presented with respect to the proposed markets for the sale of gas for resale in Greenville, Kingsport, and Jefferson City, Tennessee. The examiner found that the other proposed sales for resale, in Morristown, Johnson City, Elizabethton, and Bristol, Tennessee, would be in the public interest, when the other requirements have been met by East Tennessee. East Tennessee also has entered into agreements for direct sale for industrial use.

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Predetermines exact position and depths of pipes, cables, drains, etc.

Wilkinson Products Co.

Originators of small, light all-purpose locators

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Notice of Withdrawal Becomes Effective

The notice of withdrawal of application filed September 8 by Associated Natural Gas Company, of Tulsa, Oklahoma, in connection with its proposal to construct pipe line facilities to be used to supply natural gas to several communities in eastern Missouri, has become effective in accordance with the Federal Power Commission's Rules of Practice and Procedure.

FPC's rules provide that a notice of withdrawal shall become effective after 30 days unless otherwise ordered by the commission. The company said that it was not able at this time to negotiate firm commitments for sufficient gas to supply the prospective demand.

The company had proposed to build a total of about 32 miles of pipe line to provide service to Jackson, Portageville, Gideon, Morley, Spoonerville, and Bernie. Estimated cost of the construction was $894,320.

Additional Work in Oxford Area Approved

The Federal Power Commission has authorized New York State Natural Gas Corporation, of New York City, and Texas Eastern Transmission Corporation, of Shreveport, Louisiana, to carry out additional drilling, plugging, and reconditioning of wells at their joint underground storage project in Westmoreland County, Pennsylvania.

The two companies originally were authorized to acquire, develop, and operate the project by an FPC order of November 1, 1950. That order specified a total of 211 wells to be drilled, plugged, reworked, and reconditioned during the years 1950, 1951, and 1952.

On June 20, 1952, the companies asked the FPC to modify the earlier authorization to permit them to drill only 59 new wells instead of 60 wells, to rework an additional 32 wells, replug an additional 20 abandoned wells, and recondition an additional 111 abandoned wells, making a total of 373 wells to be worked instead of 211 as originally authorized. Total estimated cost of the additional well work is $2,600,000.

The overall project, which is in the Oakford Storage Area, originally was estimated to cost $40,772,920.

FPC Speeds Decision In Southern Natural Case

The Federal Power Commission has acted to speed its final decision on whether Southern Natural Gas Company, of Birmingham, Alabama, should be authorized to construct pipe line facilities to connect its system with new and additional gas reserves from 13 fields in southern Louisiana and southern Mississippi.

On a motion by the company, the FPC ordered the intermediate decision procedure omitted, which means that a portion of the case involving additional gas reserves will be decided directly by the commission without the filing of a decision by the presiding examiner.

Facilities that Southern Natural proposes to construct to attach its system to the gas reserves are part of an overall application, covering facilities to increase the daily delivery capacity of the company's pipe line system from 670,000,000 cu ft of natural gas to 1,020,000,000 cu ft. Cost of the entire project is estimated at $76,000,000. The portion of the project on which the commission will render its decision directly is estimated to cost about $33,000,000.

Southern Natural, in requesting omission of the intermediate decision procedure, said that most of the gas reserves in the Louisiana and Mississippi fields are covered by contracts that are subject to a condition requiring the company to obtain FPC authorization for the facilities by dates ranging from November 3 to February 1. Southern Natural said that it might be compelled to abandon or curtail its project, to the detriment of consumers, if it loses one or more of these contracts.

The commission said that it apparently would not be economically feasible for Southern Natural to extend its system to these new gas supply sources unless it is certain of procuring all the gas, and in order to firm up all this gas it now appears necessary that the company receive authorization by November 3.

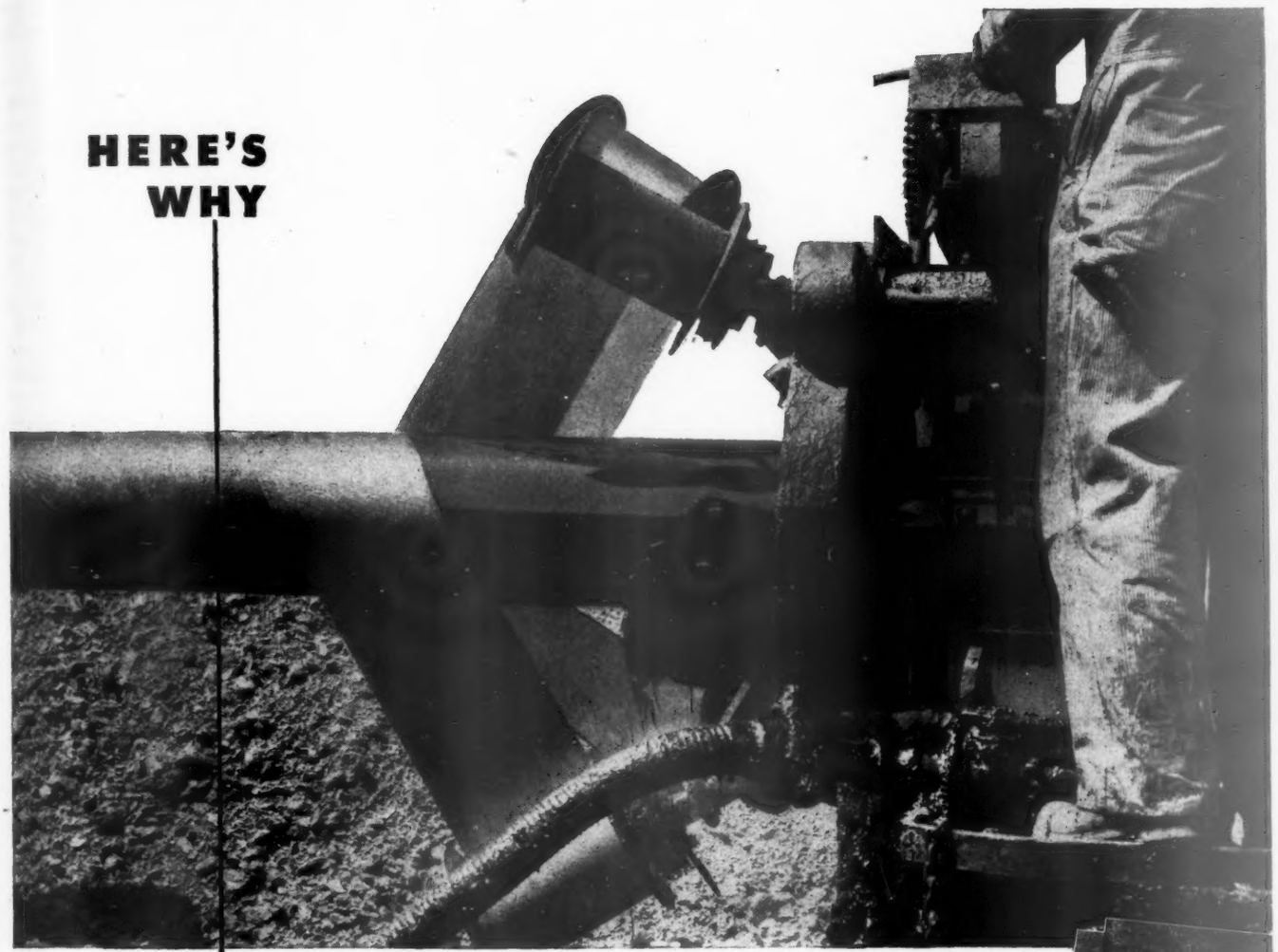
FPC Rejects to El Paso Applications

The Federal Power Commission has rejected two applications by El Paso Natural Gas Company, of El Paso, Texas, proposing the construction of pipe line facilities in Texas, New Mexico, and Arizona to increase the daily delivery capacity of its system by a total of 400,000,000 cu ft of natural gas a day for use by customers in Texas, New Mexico, Arizona, and California.

In a letter to the company, the commission said that the applications do not comply with the FPC's rules in a number of respects, particularly with respect to those sections relating to a description of the proposed operation, gas reserves, revenues, and rates to be charged.

The construction proposed by El Paso in the two applications included a total of approximately 822 miles of main transmission loop line and was estimated to cost a total of about $176,250,000.

Pipeline Enamel STAYS PUT... reinforced with Fiberglas Coromat



Two facts are clear from pipeline construction records. First, nothing equals *glass* for reinforcement and protection of pipeline enamel coatings. Second, more miles of pipeline coatings are protected by Fiberglas Coromat* than by any other glass wrap (over 700 million square feet in use).

Coromat is effective, because it makes the enamel effective! It draws permanently into the coating. Adds strength . . . keeps enamel on the pipe in uniform thickness. As it is wrapped on, Coromat helps to control loss of enamel, eliminates holidays by breaking gas and air bubbles. Once in place, this membrane of fine fibrous glass prevents heat sag and cold flow. It lessens damage to enamel from backfill impact, and increases resistance to soil stress 2 to 5 times.

In application, Fiberglas Coromat saves time and trouble. Parallel reinforced for fast, break-free wrapping—easy to handle, uniform in quality. Contact your nearest Fiberglas branch office for full information and prompt service. OWENS-CORNING FIBERGLAS CORPORATION, Dept. 55-K, Toledo 1, Ohio.

For added protection
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Tough glass-and-bitumen construction—pioneered by Owens-Corning—cushions enamel against backfill shocks, soil stresses, bumps in handling. Perforated to release air and gases. Keys firmly into enamel.

OWENS-CORNING
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ON YOUR PIPELINES . . . FOR GOOD!

*Fiberglas and Coromat are trade-marks (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for products made of or with fibers of glass.

On this pipe line construction job in Canada, the contractor, Sparling-Davis Company, Ltd., is making shot holes for blasting the ditch in a rocky area. Here a Caterpillar Diesel D7 tractor with sideboom is used for cradling the wagon drill and for towing the compressor as well.

Acquisition of Gas Facilities Authorized

The Federal Power Commission has authorized Rockland Light and Power Company, of Nyack, New York, to acquire and operate natural gas properties in Rockland and Orange counties, New York, of Rockland Gas Company, Inc., of Spring Valley, New York.

Rockland Gas Company, which owns and operates approximately 249 miles of gas lines, serves 20 communities in Rockland and Orange counties.

Decision Becomes Final in Gas Case

A decision by a Federal Power Commission presiding examiner, authorizing Frederick Gas Company, Inc., of Frederick, Maryland, to construct a natural gas pipe line, has become effective as the final decision and order of the commission. The decision was issued on August 26 and became effective in conformity with the FPC's rules since no exceptions were filed or review initiated by the commission during the following 30 days.

The decision, filed by Examiner Francis L. Hall, authorizes Frederick Gas Company to build a 26-mile natural gas pipe line from the Redlands, Maryland, area to the company's local distribution plant at Frederick. The proposed 4½-in. line, estimated to cost approximately $226,000, will connect with the system of Transcontinental Gas Pipe Line Corporation at Redlands. Frederick Gas Company now supplies manufactured gas in Frederick, and the new line will bring natural gas to that town for the first time.

Short Jersey Gas Line Authorized

The Federal Power Commission has authorized the Public Service Electric and Gas Company, of Newark, New Jersey, to construct 16.13 miles of transmission pipe line to transport natural gas received from Texas Eastern Transmission Corporation to Public Service gas works at Harrison and Jersey City.

In its authorization, the commission approved the construction and operation of approximately 11.13 miles of 16-in. line, which will extend from the Texas Eastern line at Linden, New Jersey, to Harrison. From this point of connection at Harrison, Public Service will construct approximately 2.04 miles of 12-in. and 2.96 miles of 10-in. to extend to its Harrison Gas Works at Harrison and to its West End Gas Works at Jersey City.

Atlantic Seaboard to Take Over Virginia Gas

The Federal Power Commission has authorized Atlantic Seaboard Corporation, of Charleston, West Virginia, to acquire and operate all of the natural gas transmission facilities of its subsidiary, Virginia Gas Transmission Corporation, also of Charleston. Both are affiliated companies of the Columbia Gas System, Inc.

The acquisition was proposed as a step of corporate simplification under the Public Utility Holding Company Act of 1935, and the companies expect to effect substantial savings as a result.

Seaboard and Transmission each own and operate sections of a continuous 421-mile 20-in. gas transmission line extending from Boldman, Kentucky, to the Maryland-Pennsylvania state line, and a 262-mile 26-in. line from Clendenin, West Virginia, to a point near Rockville, Maryland. Transmission owns and operates the Virginia sections of the lines, and Seaboard owns and operates the sections in Kentucky, West Virginia, and Maryland.

After the acquisition has been consummated, Seaboard will continue all services presently rendered by Virginia Gas, which sells gas to the city of Charlottesville, Virginia, Lynchburg Gas Company, Roanoke Pipe Line Company, Commonwealth Natural Gas Corporation, and Virginia Gas Distribution Corporation.

The acquisition will be accomplished by a declaration of a dividend by Virginia Gas, payable to Seaboard, of an amount equal to its earned surplus since September 30, 1946. Atlantic Seaboard will then dissolve Virginia Gas and acquire all its assets and assume its liabilities.

Panhandle Eastern Gets Temporary FPC Approval

The Federal Power Commission has granted temporary authorization to Panhandle Eastern Pipe Line Company, of Kansas City, Missouri, for the construction of 19.7 miles of pipe line and a new 330-hp compressor station on its natural gas transmission system in Illinois.

New facilities will be used to deliver increased requirements to customers served off Panhandle's Peoria pipe line, and the lateral lines that extend from it. The construction will include 6.5 miles of line in Logan County and 13.2 miles in Sangamon County. The new compressor station will be in Peoria County. Estimated cost is $948,000.

Salt Lake Pipe Line Completion Advanced

The Salt Lake Pipe Line Company announces that its new 320-mile products line between Salt Lake City and Boise, Idaho, will be completed a month earlier than previously expected. Completion was scheduled for January 1; it is now set at December 1. C. E. Finney, Jr., president of Salt Lake Pipe Line Company, said a change in the steel production outlook had caused the revision in construction time.

VULCAN NEEDED AN ANVIL...

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Philco Microwave equipment is designed for utmost reliability, flexibility and ease of maintenance... qualities demanded without compromise by the Armed Forces. Philco's ability to surpass these rigid standards provided the Armed Forces with an immediate source of vital communications equipment.

Today, as always, forward-thinking Philco stands ready to develop and produce advanced electronics equipment to meet any need of the Government and the Armed Forces.

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PHILCO CORPORATION

GOVERNMENT AND INDUSTRIAL DIVISION

PHILADELPHIA 44, PENNSYLVANIA

With the PIPE LINE CONTRACTORS

Dunn Brothers, 801 Mercantile Securities Building, Dallas, Texas, are stringing pipe on the 333-mile line looping the system of Salt Lake Pipe Line Company. The pipe from Salt Lake City to Snowville, Utah, is Somastic coated and from that point on to its termination at Boise, Idaho, bare pipe that is being coated on the job with enamel. Prime contractors are Macco Corporation and Engineers Limited Pipe Line Company.

Other stringing jobs are:

For Texas Eastern Transmission Corporation, 315 miles in Louisiana and Texas. The prime contractor is H. B. Zachry Company.

An undetermined amount of pipe in the Rio Grande Valley of Texas for Tennessee Gas Transmission Company.

Hauling an undetermined amount of pipe from Texas and Missouri to the vicinity of Joliet, Illinois, for Texas Illinois Natural Gas Pipeline Company. Ray L. Smith and Son are the prime contractors.

Hauling and stringing an undetermined amount of pipe for El Paso Natural Gas Company in Arizona.

Hauling approximately 140 miles of 8 and 10-in. in the vicinity of Madisonville, Corsicana, and Teague on The Texas Pipe Line Company system. Prime contractors are Lone Star Constructors and Carl Dunn.

The work for Conyes Construction Corporation on the Ohio Oil Company system in Ohio and Illinois is being wound up.

Macco Corporation, 14409 South Paramount Boulevard, Paramount, California, has begun work on 113 miles of 8-in. products pipe line from Salt Lake City to Snowville, Utah, for the Salt Lake Pipe Line Company. This is part of a 333-mile line from Salt Lake City to Boise, Idaho, paralleling the company's existing system. The main project office is at Ogden, Utah. One spread is working out of Salt Lake City. Al Anthony is superintendent. A second spread is working from Snowville. Kenny Sills is superintendent.

Mary Construction Company, Cape Girardeau, Missouri, recently began laying 51 miles of 14-in. in Illinois for Shell Oil Company. The field office is at Litchfield, with Roy Whitworth superintendent and Carl Wiist office manager.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa, Oklahoma, makes the following construction progress report, as of October 14:

Aluminum Ore Company, Bauxite, Arkansas: Process piping, fabrication 90 per cent completed; installation 70 per cent completed. Earl S. Powell, superintendent; Morris Garey, office manager, and Ralph Bray, area superintendent.

Natural Gas Pipe Line Company of America, Chicago, Illinois: Manifold alterations at Station 107, Emerson, Iowa, completed; manifold alterations at Station 108, Truro, Iowa, completed.

Sinclair Pipe Line Company, Independence, Kansas: Construct pump station, Quincy, Illinois, 55 per cent completed. Ray M. Johnson, superintendent; Charles Malone, engineer, and W. D. Kaufman, office manager.

Install piping at Humbolt, Kansas, station, 45 per cent completed. W. E. Taylor, superintendent, and J. A. Stokes, office manager.

Construct pump station, Pontiac, Illinois, 45 per cent completed. K. L. Kreamalmyer, superintendent; Fred Trompler, engineer, and O. L. Westrum, office manager.

Panhandle Eastern Pipe Line Company, Kansas City, Missouri: Erect finfan towers at Pleasant Hill, Illinois, 10 per cent completed. J. M. Graham, superintendent, and R. E. Brewer, office manager.

Ray L. Smith and Son, Inc., Hazlett Building, El Dorado, Kansas, laying 20 miles of 30-in. pipe from Dwight to Herscher, Illinois, for the Natural Gas Storage Company of Illinois, had completed the right-of-way and strung 50 per cent of the pipe by the middle of October, and were kicking off on ditch, lay, dope, etc. The entire job is expected to be completed by November 30. D. E. Whitworth is superintendent and D. L. Marley office manager.

This contractor is installing seven 12-in. river crossings for Standard Oil Company (Indiana) on its products line from the Sugar Creek Refinery at Kansas City, Missouri, to Dubuque, Iowa. Three have been completed and work is in progress on the Des Moines River near Ottumwa, Iowa, and the Cedar River near Cedar Rapids, Iowa. C. O. Taylor and C. Colvin are the superintendents, and J. H. Salisbury office manager.

Associated Pipe Line Contractors, Inc., 3272 Westheimer Road, Houston, Texas, has been awarded a contract by The Texas Pipe Line Company to take up a 10¾-in. oil pipe line from Erath, Louisiana, pump station west to the Sabine River, a distance of approximately 106 miles. The pipe will be reconditioned and used elsewhere. Recovery of this section of line is made possible by Texas Pipe Line's new 22-in. crude oil line extending from Houma, Louisiana, to Port Arthur, Texas.

The contractor expects to complete sometime in November the 200 miles of 3-in. through 16-in. pipe line under construction in Massachusetts, Rhode Island, and Connecticut for Algonquin Gas Transmission Company. One field office is at Taunton, Massachusetts. L. H. Gray is superintendent, Jack Bradley office manager, and L. F. Shontel master mechanic. The second field office is at Norwich, Connecticut, where Cecil Rogers is superintendent and James Luther office manager.

Engineers Limited Pipe Line Company, 225 Bush Street, San Francisco, California, will lay 220 miles of 8-in. products pipe line for Salt Lake Pipe Line Company, part of a 333-mile line from Salt Lake City to Boise, Idaho. The section will be from Snowville, Utah, to Boise, Idaho. The line parallels the company's present system. The work is scheduled for completion by the end of the year. The central office is at Twin Falls, Idaho, with Bill Webb in charge. There are three spreads. No. 1 spread has its field headquarters at Mountain Home, Idaho, with Louis Robinson superintendent, and Pat O'Toole office manager. No. 2 spread is working out of Burley, Idaho, with C. E. Hamilton superintendent, and Lyle Leon office manager, and No. 3 spread has its headquarters at Twin Falls with Bill Cook superintendent, and Art Strouse office manager. A river crossing crew in charge of R. B. Wilson is working from Glenns Ferry.

The contractor also is laying 78 miles of 8-in. in Wyoming for the Pioneer Pipe Line Company. The field office is at Evanston. Lynn Vassar is superintendent and Harvey Montague office manager.

Anderson Brothers Corporation, 6300 Navigation Boulevard, Houston, Texas, has resumed work on the Rancho Pipe Line Company between McCamey and Cedar Valley, Texas. This 266 miles of 24-in. has been delayed due to pipe shortage. To the middle of October 122 miles had been completed. The field office is at Menard, Texas, with Aldress Kilgore superintendent and Karl Smith office manager.

F. E. Shaw Limited, P. O. Box 291, Sarnia, Ontario, Canada, began work September 15 on 45 miles of 10-in. pipe line for Union Gas Company of Canada, Ltd., between Glencoe and Komoka. Work also is in progress on pump stations at Ottawa and Kingston for Shell Oil Company, Ltd.

Western Pipe Coating Company, Inc., P. O. Box 181, Iola, Kansas, has subcontracted from Engineers Limited Pipe Line Company the coating of 140 miles of 8-in. pipe on the Salt Lake Pipe Line Company system, a products line. The section is from the southern Idaho border to Boise. The north spread has Cecil D. Carey as superintendent and Chester C. Hall spread foreman. C. M. "Peewee" Vaughn is superintendent of the south spread and H. W. Carey foreman. Ralph Sinclair is office manager for both spreads.

Altgelt Construction Company, Inc., P. O. Box 1402, Corpus Christi, Texas, will complete about December 1, 53 miles of 6 and 8-in. pipe line in Scurry County, Texas, for the Sun Pipe Line Company. The field office is at Colorado City, Texas. Lee Phillips is superintendent and Art Roberts office manager.

Trojan Construction Company, 1416½ North Robinson, Oklahoma City, Oklahoma, is taking up 400 miles of 8, 10, and 12-in. pipe for the Ohio Oil Company, of which a part is being reconditioned. The work is in Indiana and Ohio and was sub-contracted from Conyes Construction Corporation. The field office is at Rushville, Indiana. W. E. "Slim" Deaver is superintendent and Palmer Davis office manager. This job is scheduled for completion about November 1.

Comstock Midwestern, Ltd., 206 Laird Drive N. Leaside, Ontario, Canada, has been at work since late in May on 472 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, which will extend from Edmonton, Alberta, to Vancouver, British Columbia. The central project office is at 3390 Kingsway, Vancouver. The telephone number is Dexter 5511. C. C. Bledsoe is project manager, Charles Rathgeb, Jr., assistant project manager, M. T. "Bill" Wilhite general superintendent, A. T. Tolbert assistant superintendent, and Mike Seville office manager.

The three spreads are located as follows:

Jasper, Alberta: Joe Work spreadman, D. E. Anderson office manager, and Herb Allen master mechanic.

Valemount, British Columbia: E. H. Work spreadman, and N. O. Boies office manager.

Chilliwack, British Columbia: Herschel Howard, superintendent; Charline C. Boies, office manager.

H. C. Price Co.—Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 363 miles of 26-in. high pressure natural gas loop lines for Texas Gas Transmission Corporation from east bank of Mississippi River near Greenville, Mississippi, to Jeffersontown Station, Kentucky, a few miles east of Louisville. Spreads are as follows:

Clarksdale, Mississippi, 1724 Ford Street; telephone 2001: C. R. Ice, superintendent; G. A. Harvey, office manager; C. E. Birmingham, equipment foreman; Jesse Cash and W. O. Elliott, right-of-way foremen; E. W. Whisenant, ditch; Forest Loinette, bending; W. T. Dickerson, pipe; L. O. Reutzel, welding; N. D. Adams, coating; J. C. Rich, lower-in, and J. E. Hamilton, cleanup.

This spread was assigned to loops totaling 135 miles.

Memphis, Tennessee, P. O. Box 7007; telephone 48-2285: C. E. Shivel, superintendent; D. H. Johnston, office manager; Boyd Danner, equipment foreman; E. D. Worley, road crossing foreman; C. F. Jones and R. H. Edwards, right-of-way; Ray Drewell, ditch; Virgil Huff, bending; R. E. Carriker, pipe; John Stokes, welding; Henry Hill, coating; Bill Buchanan, lower-in, and Paul McCormick, cleanup.

This spread assigned to loops totaling 59 miles; pipe gang scheduled to start latter part of October.

Byersburg, Tennessee, general delivery; telephone 280: R. L. Ezell, superintendent; W. R. Crego, office manager; Tommy Stammer, equipment foreman; Cleo Robertson, road crossing foreman; J. D. White, right-of-way; W. H. Olrich, ditch; J. H. Latham, bending; Delbert Shivel, pipe; J. H. Riley, welding; J. B. Northcutt, coating; C. W. Sisco, lower-in, and S. L. Price, cleanup.

This spread was assigned to loops totaling 80 miles.

Princeton, Kentucky, general delivery; telephone 2083; G. A. Reutzel, superintendent; W. E. Yount, office manager; J. H. Ingram, equipment foreman; K. N. Adkins, road crossing; J. A. Hairston, right-of-way; Lloyd J. Loncarich, ditch; J. C. Anderson, bending; H. C. Morrison, pipe; R. W. Orr, welding; S. J. Wood, coating; Athel Bell, lower-in; T. E. Walker, cleanup, and Charles Schooler, warehouseman.

H. C. Price Co.—Somastic Division, P. O. Box 1111, Bartlesville, Oklahoma, has the following jobs in progress at its Bustleton, Pennsylvania, plant:

Philadelphia Gas Works Company—Application of Somastic coating to 112,085 ft of pipe ranging in size from 1 to 30 in.

Gulf Oil Corporation—Application of Somastic coating to 52,135 ft of pipe ranging in size from 6 to 24 in. Application of Hevicote to 9300 ft of 8, 12, and 16-in. pipe.

Okonite-Callender Cable Company—Application of Somastic coating to 11,005 ft of 6-in. pipe.

Philadelphia Electric Company—Application of Somastic coating to 92,485 ft of 4 and 8-in. pipe.

South Jersey Gas Company—Application of Somastic coating to 11,319 ft of 8-in. pipe.

C. J. McGonigal—Application of Somastic coating to 2322 ft of pipe ranging in size from 3 to 12 in.

California Oil Company—Application of Somastic coating to 32,103 ft of 8-in. pipe.

W. K. Mitchell Company—Application of Somastic coating to 900 ft of 8-in. pipe.

At the Harvey, Louisiana, plant:

L. E. Farley, Inc. (For Interstate Natural Gas Company, Inc.)—Application of 9/16-in. of Somastic and 1⅝-in. of Hevicote to approximately 30 miles of 16-in. pipe.

J. Ray McDermott and Company, Inc. (For Humble Oil and Refining Company)—Application of Hevicote to approximately 14,000 ft of 10¾-in. pipe.

Massey Pipe Line Construction Company, P. O. Box 2099, Corpus Christi, Texas, is taking up 78 miles of 10-in. for Gulf Pipe Line Company between Wortham and Weatherford, Texas. The field office is at Wortham with Buck McIntyre in charge.

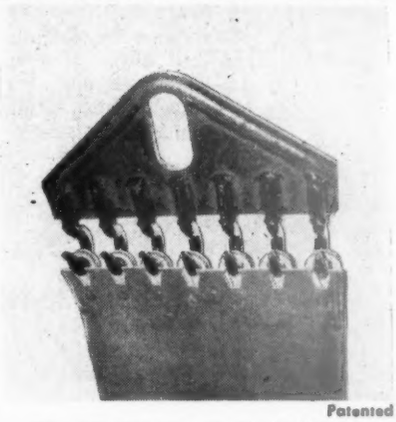
Sheehan Pipe Line Construction Company, 529 National Bank of Tulsa Building, Tulsa, Oklahoma, is installing a crossing of the Kankakee River near Kankakee, Illinois, for Phillips Pipe Line Company. Involved is one mile of 8-in. pipe. C. M. Brown is superintendent. This job began October 10.

O. R. Burden Construction Corporation, 6702 East 21st Street, Tulsa, Oklahoma, recently contracted to take up 600 miles of 6, 8, 10, 12, and 14-in. pipe for Sinclair Pipe Line Company between Drumright, Oklahoma, and Humboldt, Kansas, and has moved two spreads onto the job. At Wynona, Oklahoma, Paul Thibodaux is superintendent. A spread at Chanute, Kansas, is in charge of Ted Price.

Another take-up job for Sinclair is in Missouri and Illinois. This consists of 425 miles of 8 and 12-in. between Salisbury, Missouri, and Wood River, Illinois. Spreads handling this work have their headquarters at Moberly and Troy, Missouri.

The contractor has five spreads on the job for Sinclair between Quincy, Illinois, and East Chicago, Indiana, laying 210 miles of 22-in. pipe line. Spread No. 1 has its headquarters at Astoria, Illinois, where Floyd Lewis is superintendent and Howard Smith office manager. Spread No. 2 is working from Peotone, Illinois. A. T. Perry is superintendent and Kelley Strickland office manager. Spread No. 3 is at Tremont, Illinois, with A. B. Haynes the superintendent and Bernie Seagle office manager. Spread No. 4 has its field headquarters at East Chicago, Indiana. Here Fred Byers is general superintendent, Fred Peters spreadman, and Bill Clyma office manager. The fifth spread also has its headquarters at East Chicago. "Rube" Dodson is in charge.

SUPERIOR BELT SLING



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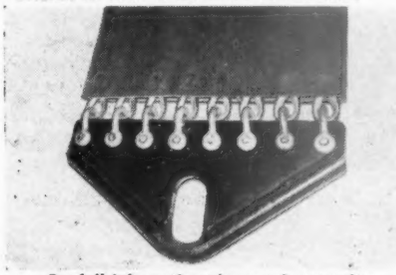

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Pipe Line Contractors

L. E. Farley, Inc., 2609 Sunset Boulevard, Houston, Texas, has contracted to lay 64 miles of 16-in. for the Interstate Oil Pipe Line Company between Morgan City and Baton Rouge, Louisiana. This work may not get underway until after the first of the year due to delay in pipe shipments.

Reese Brothers Construction Company, Hugoton, Kansas, is laying a gathering system from Guymon, Oklahoma, to Garden City, Kansas, for Northern Natural Gas Company, consisting of an undetermined amount of 4-in. through 12-in. pipe. Work has been shut down for some time due to pipe shortage with 50 miles laid. Paul G. Reese is superintendent, Edgar H. Reese spreadman, Gale Reese welder foreman, and Frederick Fallert office manager.

Houston Contracting Company, 2707 Ferndale Place, Houston, Texas, has the following construction under contract:

Approximately 88 miles of 24-in. gas line for Southern Natural Gas Company in Mississippi and Alabama. There are two spreads as follows:

About 42 miles in the vicinity of Louisville, Mississippi, where the field office is situated. The telephone number is 970. F. A. Silar is superintendent; L. F. Readfearn, office manager; Ralph West and J. M. Shires, right-of-way foremen; J. D. Riley, ditch; R. L. Silay, bending; J. O. Shoalmire, pipe; A. E. Benham, welders; Paul Taylor, dope; H. J. Guidroz, lowering-in and tie-ins; Ben Bennett, clean-up; H. B. Hutchinson, materials; J. F. Nolan, timechecker, and George Mueller, chief inspector.

Approximately 42 miles from Reform, Alabama, to the Warrior River. The field office is at Northport, Alabama; telephone 2-1216. W. H. Hayes is superintendent; M. L. Thompson, assistant; J. C. Strickler, office manager, and Louis Young, welding foreman. Pipe started October 1.

The entire 88 miles of pipe is being double-jointed at the Republic Steel Company pipe mill at Gadsden, Alabama. H. J. Muckley is in charge with R. R. Rice the welding foreman.

For Rancho Pipe Line Company, 126 miles of 24-in. from the west bank of the Brazos River to Austin, Texas. The field office is at Columbus, Texas. E. C. Norris is superintendent; R. E. Thornton, assistant; R. J. Axsom, office manager, and Jack Slovak, welding foreman. Work scheduled to resume about November 1 after shutdown due to pipe shortage.

Approximately 51 miles of 16-in. crude oil line for Interstate Oil Pipe Line Company from Sunset, Louisiana, east to the Mississippi River at Anchorage, Louisiana. The field office is at Opelousas, Louisiana. H. L. Leake is superintendent; S. B. Harrison, assistant, and H. C. MacWhinnie, office manager.

H. L. Gentry Construction Company, 921 East Michigan Avenue, Jackson, Michigan, is laying approximately 23 miles of 12 and 16-in. pipe for Home Gas Company in the vicinity of Binghamton, New York. R. L. Cantrell is superintendent; Robert Groth office manager.

Oklahoma Pipe Line Constructors, 6612 Hines Boulevard, Dallas, Texas, resumed work October 17 on the Rancho Pipe Line Company system after a considerable shutdown due to pipe shortage. With 18 miles left to lay, the work was scheduled for completion about November 1. In all, the contractor laid 68 miles of 24-in. as a joint venture with Houston Contracting Company, the section extending from Shell's refinery at Pasadena, Texas, west to the Brazos River. The field office is at Rosenberg with Ed Flanagan superintendent, Henry Scherer office manager.

Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma, is doing considerable work at present for Mid-South Gas Company of Little Rock, Arkansas. A city distribution system is being installed at Paragould, Arkansas, which consists of approximately 35 miles of pipe 2-in. through 6-in. This job began October 15. On that same date work began on a 4-in., 13-mile lateral to Paragould. Another lateral for MidSouth, which has not yet started, will consist of 47 miles of 3-in. through 6-in. pipe. The field office is at 407 North Pruitt, Paragould; telephone 2047. Curt Vaughan is general superintendent and J. W. Tyner office manager.

Work got underway October 25 on 20 miles of 6 and 8-in. for the Kansas-Nebraska Natural Gas Company in the vicinity of McCook, Nebraska. The field office is at that point, with Earl Hackelman spreadman and V. L. Bethel office manager.

A small gathering system, 12 miles of pipe up to 10 in. diam, is being laid for the Colorado Interstate Gas Company at Keyes, Oklahoma. This job began October 15. The field office is at Ulysses, Kansas; telephone 7. Ivan Cordell is spreadman; Dave Wells office manager.

Rumsey Brothers Pipe Line Construction Company, 4039 North Broadway, Wichita, Kansas, is nearing completion of the 100 miles of 20-in. for Platte Pipe Line Company, between Marysville, Kansas, and St. Joseph, Missouri. The field office is at Hiawatha, Kansas. Myrl Rumsey is superintendent and Glenn Stitt office manager.

J. L. Cox and Son, Raytown, Missouri, are stringing 340 miles of 22-in. pipe between Salisbury, Missouri, and Shrerville, Indiana, on the Sinclair Pipe Line Company system. Other jobs for Sinclair are 400 miles of 8 and 12 in. from Shannondale station to Wood River station, and 600 miles of 8, 12, and 14-in. pickup from Manuel station, Oklahoma, to Independence, Kansas.

H. B. Zachry Company, P. O. Box 2570, San Antonio, Texas, has contracted 315 miles of 24-in. from Texas Eastern Transmission Corporation, between Provident City, Texas, and Castor, Louisiana. Central office is at Huntsville, Texas; telephone 1683. D. D. Shrum is the general superintendent. One spread has its office at Columbus, Texas, with Billy Cole the superintendent. The other is at Logansport, Louisiana, with W. F. Huff the superintendent.

Harford Brothers Pipe Line Construction Company, Emporium, Pennsylvania, has laid part of its 75-mile section of 10-in. pipe for Lake Shore Pipe Line Company but has been delayed by the pipe shortage. The section extends from Cochranton, Pennsylvania, to Ashtabula, Ohio, then west to Fairport Harbor, Ohio. The field office is at Linesville, Pennsylvania. Arthur Harford is superintendent and Earl Dell spreadman.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, is laying 112 miles of 6, 10, and 12-in. pipe line in Colorado for the Toronto Pipe Line Company. The field office is at Sterling, Colorado. Oscar Phillips is superintendent and G. M. Shorts office manager. The job began September 25.

Work is in progress on 55 miles of 8-in. products pipe line for Pioneer Pipe Line Company between Salt Lake City, Utah, and Sinclair, Wyoming. The spread is working out of Salt Lake City. Jerry Nash is superintendent.

Work is nearing completion on the Platte Pipe Line Company system. The contractor now has his field headquarters at Holdrege, Nebraska, with A. A. Carrigan superintendent and Dave Wagner office manager. This will complete 433 miles laid from Casper, Wyoming, to Holdrege.

Williams Brothers Company, National Bank of Tulsa Building, Tulsa, Oklahoma, has offices at Atlanta, Georgia (Telephone 47-4341) and Charlotte, North Carolina (Telephone 6-3418). Buddy Franks is general superintendent, Bob Folk and Joe Breedlove office managers, and E. U. Mahaffey and Brownie Young general foremen. The following work is being done:

Distribution lines at Atlanta, Chamblee, and East Point, Georgia.

Distribution lines at Kramerton, Gastonia, and Burlington, North Carolina.

Delivery lines at Thrift, North Carolina, for McCoy Oil Company. Piping for Sinclair Oil Company terminal at Atlanta and Greensboro, North Carolina.

Williams-Austin Company, Grant Building, Pittsburgh, Pennsylvania, began work November 1 on 29 miles of 20-in. pipe line for New York State Natural Gas Company. The section is between Tonkin station and Kittanning, Pennsylvania. Ralph Gaddy is superintendent and E. E. Mayes timekeeper. The job will be completed about December 15. Completed November 1 for the same company was 11 miles of 16-in. in the Renova, Pennsylvania, area, with H. C. Bauer superintendent and R. H. Condry timekeeper.

Lone Star Constructors, 10th Floor, Mercantile National Bank Building, Dallas, Texas, had completed (October 21) approximately 70 per cent of the takeup for The Texas Pipe Line Company from Concord station, north to Corsicana, Texas. This job consists of about 70 miles of 8 and 10-in. pipe. Field headquarters are at Teague. H. A. "Red" Wylie is the superintendent and Joe Freeman office manager.

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CONTRACTORS

PHONE 5-5231 LUBBOCK, TEXAS BOX 1526

Pipe Line Contractors

P. & S. Constructors, Inc., Cape Girardeau, Missouri, has 276 miles of 14-in. pipe line under construction for Shell Oil Company between Wood River, Illinois, and East Chicago, Indiana. The field office is now at Taylorville, Illinois. A. G. "Arkie" Hobson is superintendent and V. E. Connor office manager.

Fulton and Brodie Construction Company, P. O. Box 2064, Amarillo, Texas has contracted and is at work on 76 miles of 20-in. for the West Texas Gulf Pipe Line Company between Wortham and Longview, Texas. The field office is at Tyler. Charley Fry is spreadman and Hugh Hall office manager.

Anderson International Contractors, Ltd., 10330 104th Street, Edmonton, Alberta, Canada, will lay approximately 100 miles of 12-in. for Canadian Gulf Pipe Line Company. Two spreads are in the field. One spread has its offices at Edmonton with Dick Leonard in charge. The other is working out of Camrose, Alberta. Ray Bendure is superintendent and Frank Hindman office manager.

Britton Contracting Company, Inc., 93 South Main Street, Washington, Pennsylvania, began work the early part of September on 108 miles of 8-in. between Fostoria and Hudson, Ohio, the Sun Pipe Line Company. Field headquarters are at Tiffin, Ohio. Fred McKenzie is superintendent and George Fleming office manager. Also has 17 miles of 12-in. under construction for Cumberland and Allegheny Gas Company from Keyser, West Virginia, to Cumberland, Maryland. Office is at Rawlings; Frank Hart superintendent.

Brown Lite Company, 135 North Sheridan Road, Tulsa, Oklahoma, is taking up 185 miles of 6-in. pipe between Stoy, Illinois, and Hagerstown, Indiana, for the Sohio Pipeline Company. The field office is at Gosport, Indiana. A. C. Holder is superintendent, Carl Huffaker office manager, and Ray E. Curtis mechanic.

Bishop and Lock Construction Company, 1018 Magnolia Building, Dallas, Texas, began work October 20 on a job for Texas-New Mexico Pipe Line Company involving the laying of 42 miles of 8-in., 4 miles of 6-in., and 7 miles of 4-in. The lines will extend the existing sweet crude gathering facilities of the company in the Lovington pool in southeast Lea County, New Mexico, to the Saunders area in northwest Lea County. The field office is in the Lister Building in Lovington. Howard Laquey is superintendent and M. E. Williams office manager.

Williams Brothers de Venezuela, S. A., Maracaibo, Venezuela, began work October 1 on 170 miles of 26-in. for Creole Petroleum Corporation. Marvin Jones is the superintendent in charge.

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Canadian-Parkhill Pipe Stringing, Ltd., Toronto, Canada, is stringing 469 miles of 24-in. for Trans-Mountain Oil Pipe Line from Acheson, Alberta, to Burnaby, British Columbia. Contractors: Comstock-Midwestern, Ltd., and Canadian Bechtel. Superintendent, Jack Williams.

Panama-Williams Company, 403 Melrose Building, Houston, Texas, has 20 miles of 26-in. pipe line under construction for West Texas Gulf Pipe Line Company near Livingston, Texas, and 38 miles of 20-in. from Wortham east to Trinity. The field office is at Livingston, with M. E. "Panama" Shiflett superintendent, Gene Coulter spreadman, Cooney Shiflett assistant spreadman, and Ernest Smith office manager.

Work also has begun the take-up of 17 miles of 6-in. for The Texas Pipe Line Company near Houston.

Vaughn and Taylor Construction Company, P. O. Box 1351, Wichita Falls, Texas, is laying a gathering system in the vicinity of Odessa, Texas, consisting of 268 miles of 2-in. through 30-in. pipe, for Phillips Petroleum Company. D. D. Vaughn is superintendent and Clark Sayles office manager.

Mannix, Ltd., Calgary, Alberta, Canada, has in progress 224 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, extending from Blue River to Coquihalla Pass, British Columbia. The field office is at 412 Victoria Street, Kamloops, British Columbia. C. P. Baker is project manager, "Curley" Wilkerson spreadman, and H. Eisler office manager.

Fulghum Contracting Corporation, P. O. Box 1181, Harrisburgh, Pennsylvania, has under construction 100 miles of 4, 6, 8, and 10-in. pipe line for Algonquin Gas Transmission Corporation, sub-contracted from Associated Pipe Line Contractors, Inc. The work is in Massachusetts and Rhode Island. The field office is at 225 Chase Street, Somerset, Massachusetts. R. L. McMillon is superintendent and Walter Kankowsky office manager.

Missouri Valley Dredging Company, 222 Williams Street, Omaha, Nebraska, is installing a 3900-ft, 22-in. crossing of the Illinois River near Havana, Illinois, for Sinclair Pipe Line Company. Elton Sumrall is superintendent and George Van Horn office manager.

Ohio Pipe Line Construction Company, Granville, Ohio, has under construction 33 miles of 20-in. pipe line for the Ohio Fuel Gas Company, between Leesburg and Berwick, Ohio. The field office is at Bucyrus. Leon Ratliff and Fred Bucher are spreadmen, Evelyn Helbert office manager, and Tom Disbennett master mechanic.

Carl H. Dunn, Burkburnett Building, Fort Worth, Texas, is taking up 70 miles of 8 and 10-in. pipe between Corsicana and Madisonville, Texas, for The Texas Pipe Line Company. Carl Dunn is in charge of the work personally. The field office is at Streetman.

Higher Oil Prices Essential to Defense, IPAA Claims

The cost of exploring for, developing, and producing a barrel of oil in the first six months of 1952 was more than 60 cents higher than in the three-year period 1947-49. This was the report by the cost study committee of the Independent Petroleum Association of America given at its annual meeting in Oklahoma City recently. This represented a cost increase of 38 per cent to domestic oil producers, who have realized an average price rise of only 6.6 per cent in the same period, IPAA declared.

"The price of crude petroleum has been frozen without change at a level established in 1947. This price freeze was arbitrarily imposed by the Office of Price Stabilization without sound reasons and with no legal authority. The actions of OPS in ignoring the will of Congress and refusing to recognize the problems of oil production are a shameful page in the history of American constitutional government. When and if World War III strikes, the people of this Nation should know that bungling and unrealistic administration of price controls has been the real cause for any lack of sufficient oil to defend our country."

The committee referred to the "Four Years and Forty Hearings," in which IPAA has attempted to gain a price rise from the OPS. The report listed the history of price controls on crude petroleum summarizing happenings for the last two years.

It listed price control legislation that had been introduced in an attempt to gain decontrol of prices:

"The position of the Association that there is no legal basis or economic justification of price control of commodities in ample supply to meet current needs has also been before Congress. The legislative history of the Defense Production Act shows widespread acceptance in the Congress of the principle that price controls of commodities in ample supply are not necessary or contemplated under the Act and, in fact, serve to defeat the basic purpose of expanding productive facilities to meet defense program goals."

It concluded with other controls affecting petroleum costs.

"While the OPS has maintained an inflexible freeze on crude oil prices, other prices and wages affecting petroleum costs have been permitted to increase substantially. The reports of the Association's Cost Study Committee have shown the steady increases in every element entering into the cost of finding developing and producing crude oil. As a result of strikes in the petroleum and steel industries in 1952, increases in wages were authorized. The wage increase in the steel industry resulted in further increases in the cost of materials used by oil producers, particularly tubular goods. The regular price of these tubular goods has increased 35 to 40 per cent since the last change in crude oil prices in 1947. In addition, many producers are paying twice these prices to obtain foreign pipe imported into this country and 'conversion' pipe produced at abnormal costs.

"This record of price and wage controls has been one of rank discrimination against the oil producing industry."

The IPAA charged the PAD to obtain higher oil prices necessary to assure adequate supplies in case of war. It called upon PAD to determine expansion goals for oil productive capacity, "taking into consideration the possible loss of foreign sources of supply that may not be available when needed." A report from the IPAA revealed its findings that 52,000 wells next year, 55,000 in 1954, and 58,000 the following year will be enough to maintain a 1,000,000-bbl reserve. These drilling goals are 3000 wells per year less than PAD's estimates.

Australia Sells Oil Interest

The Australian government has sold its half ownership of Commonwealth Oil Refineries, Ltd., to Anglo-Iranian Oil Company because it cannot legally help finance a proposed $40,000,000 refinery in West Australia. Prime Minister Menzies reported that the government would have had to increase substantially its holding in the company to finance the refinery and legal counsellors had advised the constitution would not permit this.

The leader of the Labor opposition, Dr. Herbert Evatt charged that the sale sacrificed a vital defense interest under pressure from the "oil monopoly" adding the government's action dissolved a partnership between the British and Australian governments through Anglo-Iranian, in which Britain is a principal stockholder.

Texas Output Set Higher

Texas is producing a record amount of crude oil this month—its allowables being set at 3,372,252 bbl daily, an increase of 87,547 bbl over the October allowable. This is the third consecutive record allowable set by the Texas Railroad Commission.

Commissioner William J. Murray, Jr., reported that he was somewhat concerned that "we may be building our stocks too high," and if this proves true production will be cut back when the board meets in mid-November.

The producing schedule remains the same, 23 days for the state generally, and an 18-day output for East Texas.

Louisiana Conservation Commission set that state's output at 685,027 bbl daily, 3018 bbl more than October's allowable.

California Will Import Oil

Pacific Coast oil companies imported foreign crude at a rate approximating 75,000 bbl a day during the month of October, according to T. S. Petersen, Standard Oil Company of California president. In an Oil Progress Week address, Petersen pointed up the increased civilian and military demands that have come as a result of the Korean war, as well as a post-war surge of local population growth as being primarily responsible for the current crude oil shortage on the Pacific Coast.

G. H. Westby and B. B. Weatherby, seated, view the Hall of Science layout for the International Petroleum Exposition in Tulsa, with William B. Way, exposition general manager, Kent Kimball, and A. L. Solliday.

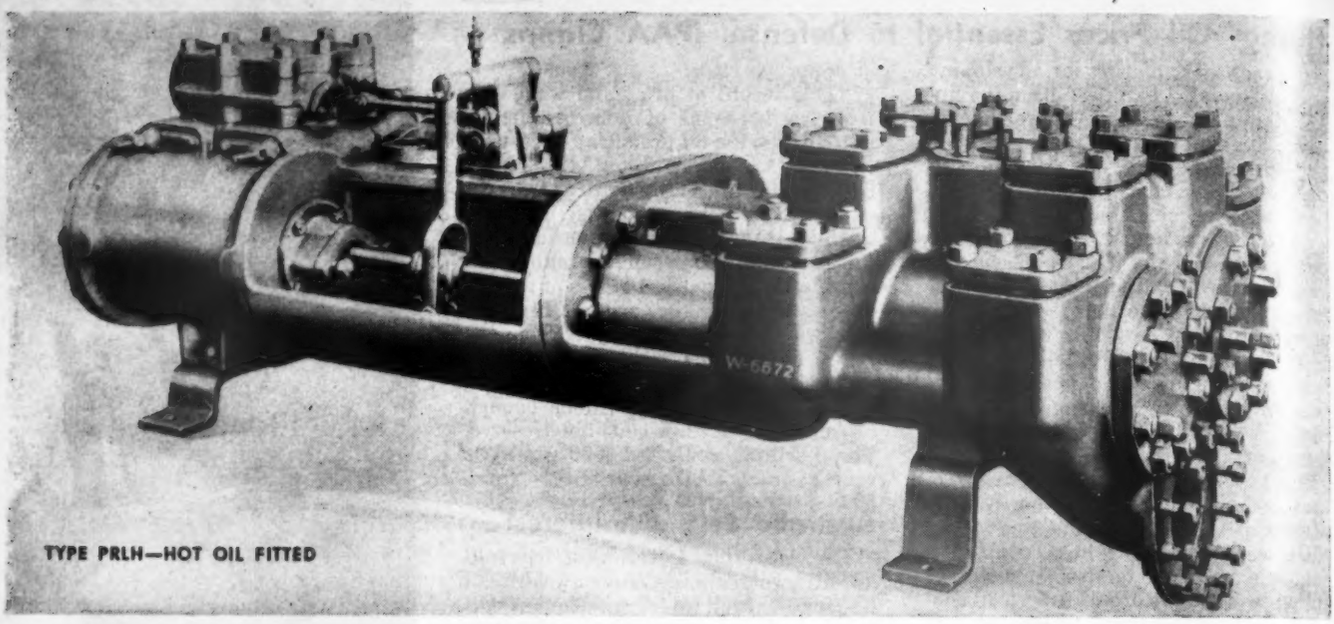
History of Oil To Be Shown

A portrayal of the history of oil, along with a pictoral explanation of the last five years of technological advancement since the last showing of the "world's fair of the oil industry," will be assembled in the Hall of Science at the May 14-23, 1953, International Petroleum Exposition in Tulsa, Oklahoma, according to W. G. Skelly, exposition president.

He announced that G. H. Westby, president of Seismograph Service Corporation, has accepted chairmanship of the Scientific and Technical Committee, which will be responsible for selecting exhibits for the Hall of Science. The committee will have some of the world's foremost technical specialists on its consulting staff, including: Dr. B. B. Weatherby, geophysicist for Amerada Petroleum Corporation, and former chairman of the committee; Dr. Gustav Egloff, director of research, Universal Oil Products, also former chairman of the committee, and A. L. Solliday, executive vice president of Stanolind Oil and Gas Company. Kent K. Kimball, consulting geologist, Tulsa, will be executive secretary of the committee.

Deep Rock Earnings Down

Deep Rock Oil Corporation net earnings for the first nine months of 1952 were $407,000 compared with $1,797,000 for the same period last year. The decline in earnings was caused mainly by increased exploratory costs, the 55-day strike in May and June, and non-recurring gains on sales of properties last year. In its "Quarterly Report to Owners" the company reported that a four-year crude production record of 9000 bbl daily was set in September.



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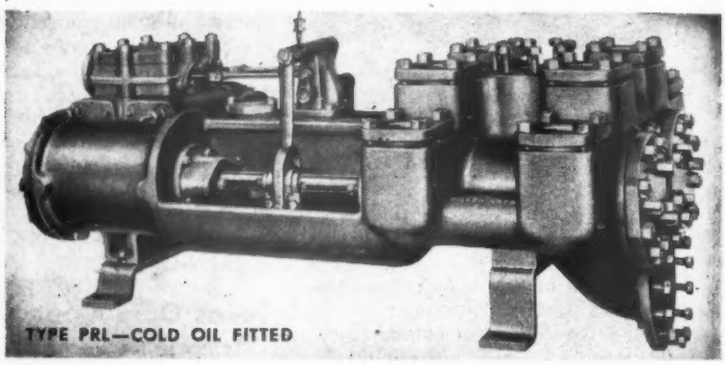
We've Built New and Superior Strength into

Worthington Steam Pumps



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Steam cylinders and flanges designed for 250 psi maximum working pressure hydrostatically tested to 375 psi . . . Drop-forged steel steam valve gear . . . Heavier piston rods . . . ½ in. minimum drain openings allow heavier pipe connections . . . Those are some of the *strength features* built into Worthington's new line of steam pumps for refinery service.

MORE FEATURES OF ADVANCED DESIGN

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This new line of duplex steam pumps represents Worthington at its best—the broadest range, the finest engineering. It's one more proof that *there's more worth in Worthington*. Write Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Reciprocating Pump Division, Harrison, New Jersey.

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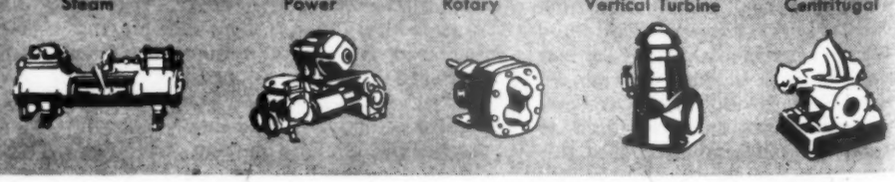


U. S. Imports, Exports Take Slight Dip

The American Petroleum Institute has reported that imports of foreign oil and products into the U. S. dropped 47,700 bbl daily during the week ended October 11 from the previous week. Daily imports averaged 905,300 bbl. Crude oil imports were down, with residual fuel up from the week before; however, a steady decline of imports of residual fuel oil this summer reflected in lower imports during August.

Exports of oil products from the U. S. dropped during the week ended September 19 to average 221,600 bbl daily. This was a decline of 18,000 bbl in a week.

Below are imports for the week October 11 and the four weeks preceding that date:

Week ended	Crude oil	Residual oil	Others	Total
September 20....	660,800	271,700		932,500
September 27....	608,500	378,400	28,300	1,015,200
October 4.....	708,900	240,200	3,900	953,000
October 11.....	612,500	275,400	17,300	905,300

Exports from the U. S., in thousands of barrels daily, for the four weeks ending September 19 are as follows:

Week ended	Avgas	Motor *gasoline	Kerosine	Distillate	Residual	Tota
August 29...	16.8	37.9	20.4	124.4	50.7	250.2
September 5.	10.6	45.1	....	69.2	27.3	152.2
September 12	85.2	5.1	5.2	77.3	66.7	239.5
September 19	25.9	16.2	26.1	107.2	46.2	221.6

Crude Stocks Up Slightly

Stocks of domestic and foreign crude petroleum totaled 263,054,000 bbl at the close of the week ended October 11, according to the Bureau of Mines. This is slightly below the total reported for the week before, October 4, 264,153,000 bbl, and September 27, 265,901,000 bbl.

Total drop from the week of October 4 was 1,099,000 bbl comprising a decrease of 1,296,000 bbl in stocks of domestic crude and an increase of 197,000 bbl in stocks of foreign crude.

Stocks rose some 1,435,000 bbl to hit the 265,901,000-bbl mark September 27, the first week crude oil stocks have not fallen since June 21. This was 10,387,000 bbl higher than a year earlier, a rise of 4.1 per cent.

Oil Conservation Urged

Conserve U. S. oil resources was the theme of Dr. Marlin M. Volz's speech to Finlay Engineering College students in Kansas City, Missouri, recently.

A teacher of oil and gas law at the University, Dr. Volz declared the conservation movement was necessary despite the fact the oil industry is much more advanced than that of any other nation, and has superior methods of discovering and developing new deposits. He commended the industry on its working with state governments to develop such conservation practices as the spacing of wells and regulation of the flow of oil so as to avoid the loss of the driving force of gas and water pressure. He added that there would be enough oil to meet the needs of an unprecedented demand for the foreseeable future.

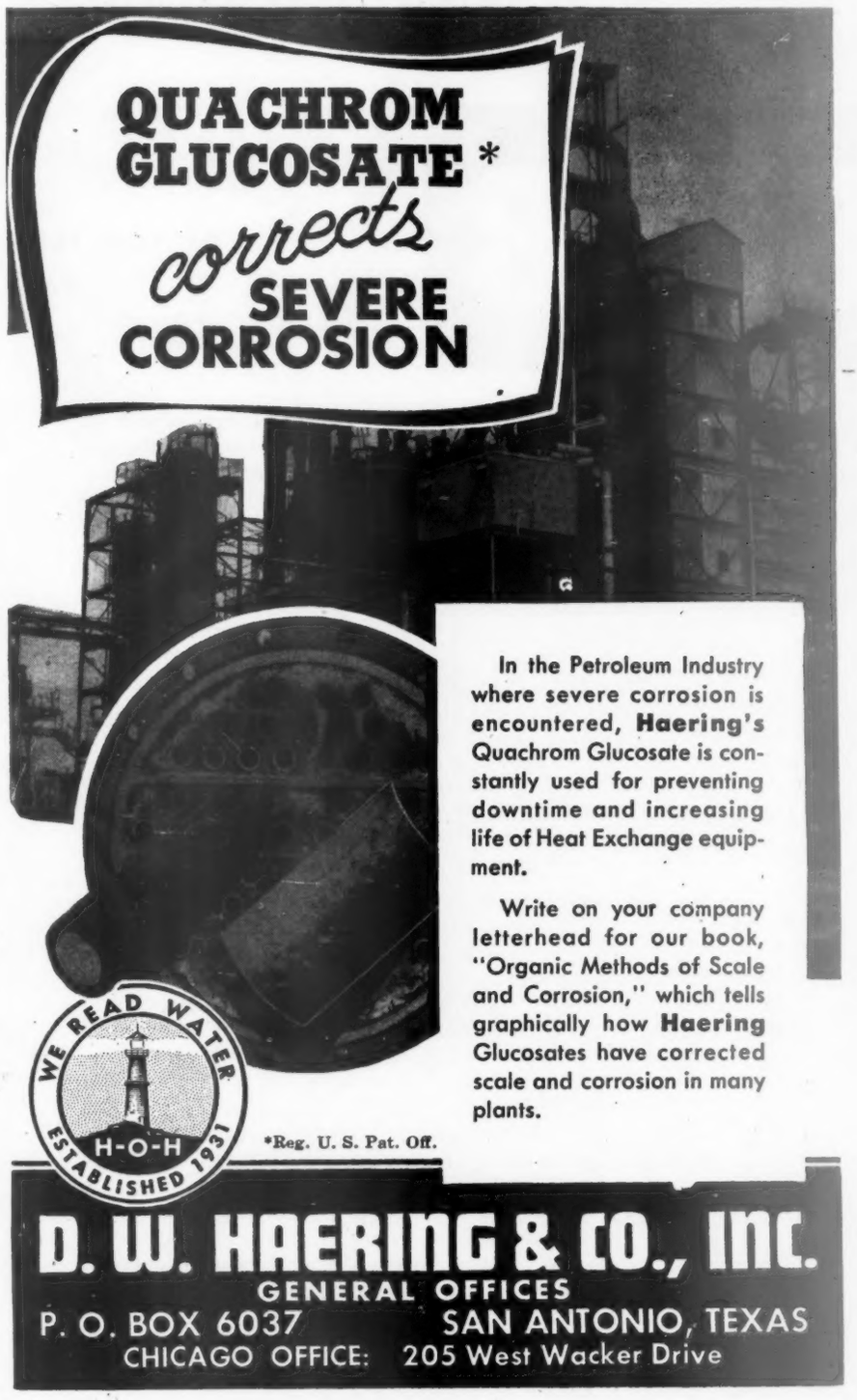
NPA Relaxes Some Rules On Construction Materials

Restrictions on the use of materials for construction projects in the oil and gas industry have been relaxed somewhat, the National Petroleum Authority has announced. In amendments to M-46 and M-46B, basic oil and gas orders, NPA raised the amount of materials that operations may use in construction projects without filing for specific permission from the Petroleum Administration for Defense.

"Small construction operation" has been broadened to include offices, warehouses, and other enclosed structures in which the total cost of all materials does not exceed $25,000. Previously any enclosed structure for which the materials cost exceeded $5000 was defined as a "large construction project," thus reducing paper work.

Revised PAD Forms Out

Revised Forms PAD-15, PAD-16, PAD-17, PAD-17DP, and PAD-32 have been made available to oil and gas operators, Deputy Petroleum Administrator J. Ed Warren reported. Although the revised forms take the place of those formerly used, PAD will continue to process applications submitted on the earlier forms up to December 15, 1952, if they contain all essential information, Warren said. After December 15, 1952, the new forms must be used.



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There's a new . . . a better way to recover condensate from gas wells

Recovery-Conscious, Profit-Wise Operators Are Doing It With The

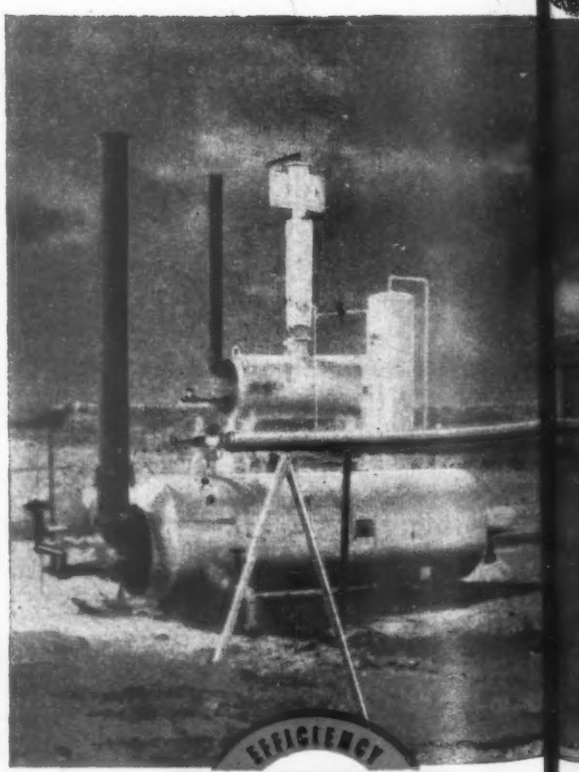
BS&B Glycol Injection System

OF LOW TEMPERATURE SEPARATION

With STABILIZER**

There's a better way . . . and BS&B has come up with it! The old way is now the costly way . . . because it fails to give the maximum recovery now possible through the BS&B Glycol Injection System of Low Temperature Separation with Stabilizer. Glycol injection permits cooling the wellstream well below the hydrate point before expansion. By using a regenerative heat exchanger lower separator temperatures can be obtained than are possible in even the most efficient conventional low temperature separation systems. This lower temperature allows a greater liquid recovery. Should the available pressure drop fall below approximately 1000 p.s.i. required for satisfactory operation of conventional low temperature separation units, the BS&B Glycol Injection System will continue to produce pipeline specification gas even with available pressure drops of as low as 400 p.s.i.

*Patented
**Patent Pending



But the recovery picture is not complete without the BS&B Stabilizer. This part of the system is today's most efficient method of getting this extra production to the stock tank—and keeping it there! The Stabilizer is a distillation column. It directs the light, wild hydrocarbons — methane, ethane, and propane—to sales. The medium and heavy hydrocarbons go to storage. The light hydrocarbons do not reach the stock tank to flash and strip the medium "easily influenced" hydrocarbons—butane and pentane—with them. You're able to keep your extra production! This much-talked-about complete recovery system can be applied to one or several wells . . . has complete versatility for off-shore or in-swamp use. Maybe you're doing it the old way . . . you'll be recovery and dollars ahead to investigate and invest in the BS&B Glycol Injection System of Low Temperature Separation *with* Stabilizer.

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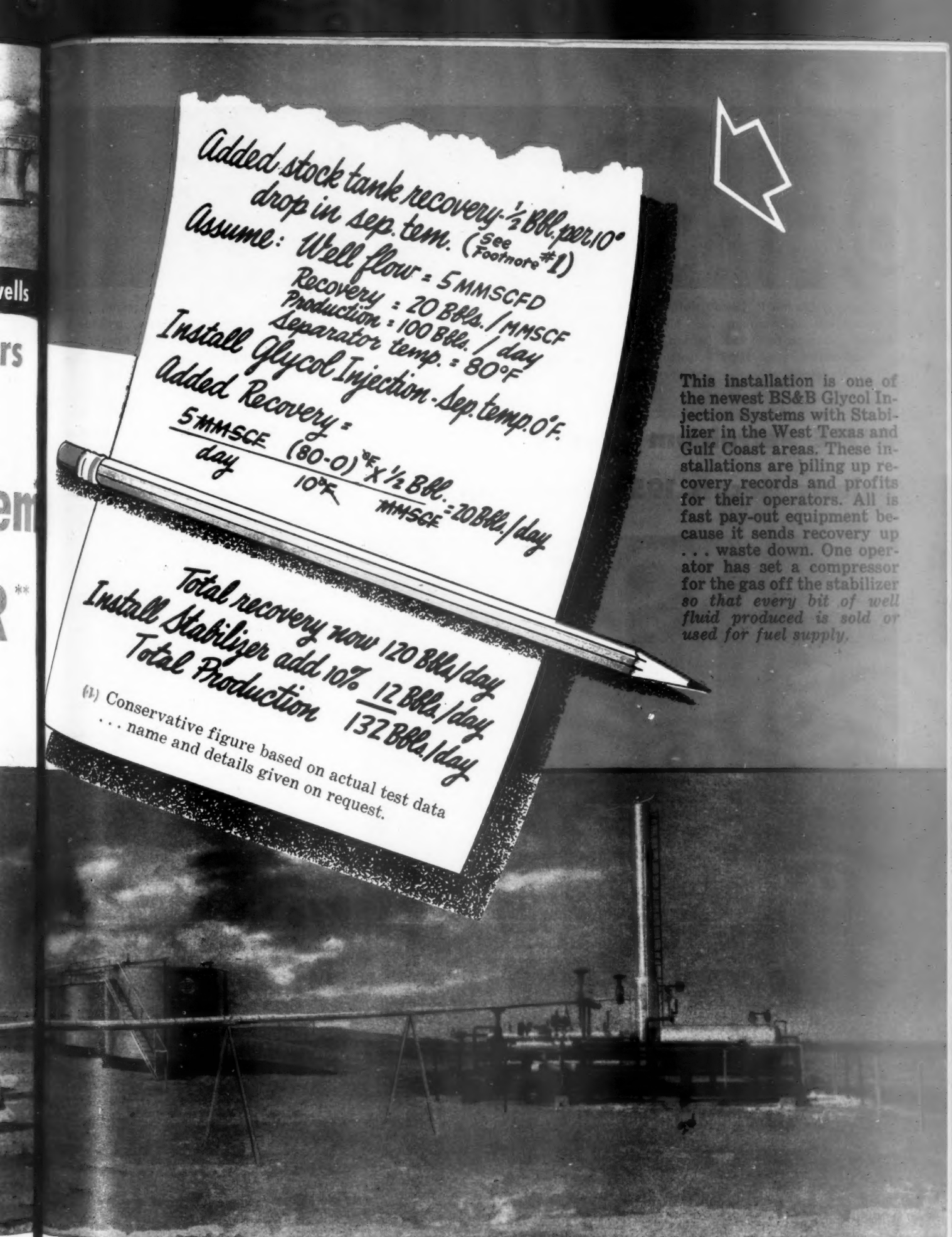
EFFICIENCY BS&B RELIABILITY OUR 60TH YEAR


Added stock tank recovery-½ Bbl. per 10° drop in sep. tem. (See Footnote #1)
Assume: Well flow = 5 MMSCFD
Recovery = 20 Bbls./MMSCF
Production = 100 Bbls./day
Separator temp. = 80°F
Install Glycol Injection - Sep. temp. 0°F.
Added Recovery =
5 MMSCF/day (80-0)°F/10°F × ½ Bbl./MMSCF = 20 Bbls./day
Total recovery now 120 Bbls./day
Install Stabilizer add 10% 12 Bbls./day
Total Production 132 Bbls./day
(1) Conservative figure based on actual test data . . . name and details given on request.

This installation is one of the newest BS&B Glycol Injection Systems with Stabilizer in the West Texas and Gulf Coast areas. These installations are piling up recovery records and profits for their operators. All is fast pay-out equipment because it sends recovery up . . . waste down. One operator has set a compressor for the gas off the stabilizer *so that every bit of well fluid produced is sold or used for fuel supply.*

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First photo, Claude R. Hocott, left, is congratulated by Paul R. Turnbull, retiring chairman, upon his election as AIME Petroleum Branch chairman for 1953. *Second,* W. S. "Buck" Morris, left, general chairman for 1952 Petroleum Branch fall meeting, and W. K. Whiteford, executive vice president, Gulf Oil, who spoke at the welcoming luncheon. *Third,* Jack M. Moore, right, chairman of Petroleum Branch membership committee, awards a speakers' rostrum banner to G. L. Yates, of the AIME Kansas section, for greatest percentage increase in membership during the first eight months of this year.

AIME Petroleum Branch Selects Hocott 1953 Chairman

Standing, H. K. McArthur, Halliburton Oil Well Cementing; R. F. Madera, Republic Natural Gas, Dallas, Texas; R. B. Beddingfield, Halliburton, Houston; and Courtney J. Berlin, Baker Oil Tools, Dallas. *Seated,* Mrs. H. K. McArthur; Leona Wimberly, Dallas; Mrs. Madera, and Elsie Haygood, Baker Oil Tools, Houston.

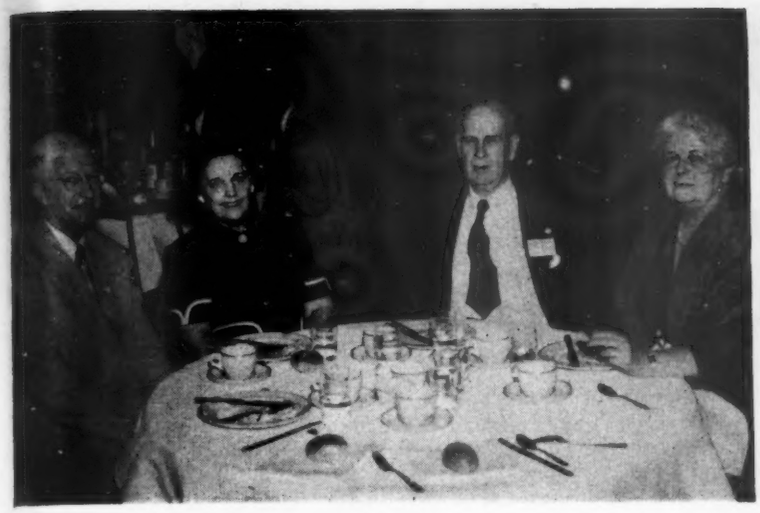
CLAUDE R. HOCOTT, assistant head of the production research division of Humble Oil and Refining Company, was named 1953 chairman of the Petroleum Branch of the American Institute of Mining and Metallurgical Engineers at its fall meeting in Houston, Texas, recently.

Other officers named at the meeting were: Vice chairmen, Basil P. Kantzer, manager of natural gas and gasoline, Union Oil of California, and John P. Hammond, assistant general superintendent of production, Amerada Petroleum Company. Two new members were named to the executive committee, Roland Gouldy, pool engineer, Hull-Silk Repressuring Association, and Thomas A. Atkinson, assistant manager of Rocky Mountain operations, General Petroleum Corporation.

General chairman for the meeting was W. S. Morris, East Texas Salt Water Disposal Company. George R. Gray, Baroid Sales Division, is chairman of the Gulf Coast Section of AIME, who acted as hosts for the meeting. Technical papers presented covered a wide range of the oil industry.

Speaker at the welcoming luncheon was W. K. Whiteford, executive vice president, Gulf Oil Corporation. A buffet supper was given the first evening for the 1533 men and 278 ladies attending the meeting, and a banquet and dance the second night.

First photo, Mr. and Mrs. James C. Blackwood, Amerada Petroleum Corporation, Midland, Texas; Mrs. R. E. Howard; R. E. Howard, Atlantic Refining, Midland. *Second,* Frank Carson, Bethel Jones, and Orien Van Dyke, all of Magnet Cove Barium Corporation, Houston, Texas, some of those who attended the banquet and dance given for those present at the meeting.



First photo, H. H. Power, University of Texas; Mrs. Power; J. O. Lewis, Petroleum Consultants, Houston; Mrs. Lewis. *Second,* Jack Stewart, Security Engineering Division, Houston; R. S. Wilson, Ohio Oil, Robinson, Illinois; John Rankin, Ohio Oil, Terre Haute, Indiana; and H. G. Bentson, Security Engineering, Whittier, California, converse before one of the exhibits at the meeting.

First photo, Warren B. Davis and N. B. Gove, Gulf Oil, Tulsa, Oklahoma; James Henderson and Frank Morgan, Gulf Research, Pittsburgh, Pennsylvania. *Second,* Mr. and Mrs. R. G. Parker, Continental Oil Company, Fort Worth, Texas; Ray Elner, Kobe, Inc., Fort Worth, and Rufus Kirk, Odessa, Texas. Approximately 1200 engineers and their wives attended the three-day meeting.

Underground Storage for LPG Planned by Industry

Facilities for underground storage of more than 2,000,000 bbl of liquefied petroleum gas—butane and propane—have been built during the last two years and additional projects now underway or planned for construction will bring total underground storage capacity for LPG to nearly 5,900,000 bbl by the end of 1953, Deputy Petroleum Administrator J. Ed Warren announced.

A survey by the Petroleum Administration for Defense shows, Warren said, that since mid-1950, when underground facilities were first built for LPG storage, 26 producing companies and LPG distributors have planned or completed a total of 77 projects, with an aggregate capacity of 5,862,500 bbl, in 12 states.

> The December issue of *The Petroleum Engineer* will be devoted to various types of storage in the petroleum industry.

About five-sixths of the underground storage capacity now planned or in use will be in producing areas in the Southwest, over 3,100,000 bbl in Texas alone, Warren said.

In Kansas City, Missouri, Neal Van Fossan told attendants at the American Society of Mechanical Engineers that the petroleum industry is searching Oklahoma and other states for underground caverns to be used as storage space for propane and butane gas. This underground storage method is now being used successfully in West Texas.

Corrosion Short Course Set

A five-day short course in corrosion will be held February 2-6, 1953, at the University of California. The course is given by the university in cooperation with the National Association of Corrosion Engineers. Speakers from industrial and governmental laboratories and academic institutions will lecture.

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World Oil 1951 Output 12 Per Cent Above 1950

Total world crude oil production in 1951 amounted to 4283 million barrel, an average of 11,700,000 bbl daily, according to the U. S. Bureau of Mines. This was a 12.8 per cent increase over 1950. Gains of 270.9 million barrels occurred in the United States, 75.4 million in Venezuela and 63.7 million in the Middle East. Production rose in the Middle East, despite the collapse of the Iranian petroleum industry in mid-1951, through material increases in Saudi Arabia, Iraq, and Kuwait.

In North America, production increased by 294.7 million barrels because of percentage increases of 13.7 in the United States, 65.8 in Canada and 6.7 in Mexico. A gain of 13.8 per cent in Venezuelan output was reflected in the increase of 82,700,000 bbl in the South America-Caribbean region.

Major production gains, percentagewise, occurred during 1951 in Europe, where production in France, as it did in 1950, doubled because of the expanding Lacq field. In Western Germany and Italy, production increased by 22.3 and 116.0 per cent respectively. The U. S. S. R. is estimated to have increased its output by 6.9 per cent. Eastern European production, exclusive of USSR, is estimated to have gained 14.9 per cent, primarily reflecting reported gains in Austria.

Production in the Middle East during 1951 averaged 1,975,000 bbl daily (1,801,000 during 1950) despite a daily average drop of 315,000 bbl in Iran. Daily production in Iraq averaged 178,000 bbl (137,000 in 1950); in Kuwait, 561,000 (344,000); and in Saudi Arabia, 762,000 (547,000). Quatar, in its second full year of commercial production, had a daily average rate of 49,000 bbl compared to 34,000 in 1950.

In the Far East, crude production in Indonesia (including New Guinea) increased 14.1 per cent. The increase in British Borneo was 21.1 per cent.

For the current year, 1952, world crude production in February averaged 12,042,000 bbl daily, an increase of 2.0 per cent over the January rate, the U. S. Bureau of Mines has reported. Daily average output in the United States was 6,367,000 bbl, up 2.4 per cent. Venezuelan production averaged 1,828,000 bbl daily compared to 1,811,000 in January. The Middle East daily average rate was 1,912,000 bbl, an increase of 1.4 per cent over the previous month. Daily average production in Iraq rose by 21.4 per cent.

Oil Cartel Booklet Out

Editorial comments and articles showing American press reaction to the Government's widely publicized charges concerning the alleged existence of an "international oil cartel" are reviewed in a booklet just published for the California Texas Oil Company, Ltd. The booklet, entitled "As U. S. Editors View the Oil Charges," contains comments by leading newspaper, magazine, and trade press observers throughout the nation.

New Directors and Officers for the Petroleum Electric Power Association are: *Standing,* W. L. Pearson, James B. Moody, W. M. Larkin, U. H. Ohrman, and B. F. Thompson. *Seated,* Ned W. Baudreau, Thomas E. Graham, Fred B. Clark, R. S. Johnson, and Paul B. Ferris.

PEPA Holds 24th Annual Meeting in Tulsa, Oklahoma

The Petroleum Electric Power Association held its 24th annual meeting at the Mayo Hotel, Tulsa, Oklahoma. The welcoming address was given by C. N. Robinson, vice president, Public Service Company of Oklahoma, on the first day of the meeting, followed by L. B. Fell, executive vice president, Independent Petroleum Association of America, and Warren Baker, editorial director, *World Oil.*

The second day's meeting was devoted to the following subjects: "Water Flooding Installations in Weber Pool of Washington County, Oklahoma" by C. W. Thomas, Public Service Company of Oklahoma, Bartlesville, Oklahoma; "Advantages of Electric Power on Water Flooding Projects," George F. Buckles, consulting engineer of Monahans, Texas; "Automatic Control Equipment for Oil Field Installations," Paul King of the Paul King Company, Tulsa; "Design of Mid-Burbank Electric Distribution System," H. J. McNally of the Kewanee Oil Company, Tulsa; "Automatic Micro-Wave Control of Pipe Line Station" by C. H. Hohnadel of the Refinery Engineering Company of Tulsa, Oklahoma; and "What's Ahead?" by Ted Workman, president, Ted Workman Advertising of Dallas Texas.

Directors and officers for the coming year are as following: Fred B. Clark, Arkansas Power and Light Company, El Dorado, Arkansas; Paul B. Ferris, The Empire District Electric Company, Joplin, Missouri; B. F. Thompson, Public Service Company of Oklahoma, Tulsa; R. S. Johnson, Texas Electric Service Company, Midland, Texas; W. M. Larkin, Gulf States Utility Company, Lake Charles, Louisiana; W. L. Pearson, Southwestern Public Service Company, vice president, Lubbock; Ned W. Beaudreau, Central Power and Light Company, president, Corpus Christi, Texas; James E. Moody, Southwestern Gas and Electric Company, secretary-treasurer, Shreveport, Louisiana; U. H. Ohrman, Texas Power and Light, Dallas; Tom D. Hoskins, Louisiana Power and Light Company, New Orleans; Frank Austin, Houston Light and Power Company, Houston, and Thomas E. Graham, Oklahoma Gas and Electric, Oklahoma City.

Oil Earnings Needed for Expansion, Swensrud Says

Oil consumption will doubtless continue upward and by 1960 U. S. demand may reach 10,000,000 bbl daily, with total world consumption, exclusive of Russia, reaching 16,000,000 bbl daily, Sidney A. Swensrud, president, Gulf Oil Company, reported in an Oil Progress Week speech recently.

He reported that to meet this demand, the oil industry would require vast sums of capital for crude oil exploration and development and for expanding all other facilities of the industry. He pointed out that since World War II the industry has already spent approximately $20 billion. Swensrud called restriction of the oil industry earnings essential to finance this expansion, the most serious threat to the industry.

Middle East Oil Vital

It is vital to this country to prevent Russia from acquiring the existing 2,000,000 bbl of oil production per day in the Middle East, Colonel Dwight T. Colley, vice president of The Atlantic Refining Company, declared in Philadelphia recently.

"We think that Russia's producing capacity amounts to about 15 per cent of this country's production, or 1,000,000 bbl daily," he said. "There are 2,000,000 bbl per day in the existing production in the Middle East, with much more available. Do you think it is important to hold this? It certainly would be vital to deny it to an enemy."

Colonel Colley pointed out that the United States, with only 7½ per cent of the world's population, consumes 67 per cent of all refined petroleum products.

U. S. Leads World In Oil Consumption

A dynamic oil industry that has enabled the people of the United States to become the world's leading users of petroleum products was described by J. C. Donnell, II, president of The Ohio Oil Company, at Oil Progress Week gatherings in Cleveland and Cincinnati, Ohio, recently.

Each American last year used an average of almost 700 gal, Donnell reported, more than the 50 gal in Europe, 35 in Australia, 20 in Africa, and 6 in Asia.

Operators must drill a greater number of new wells each year, not only to offset the normal decline, but also to meet the increasing demand, Donnell said.

Discussing the risks involved in exploratory drilling, he noted that only one wildcat well in nine proves to be productive, and only one in 16 is commercially profitable.

"The odds against finding a large oil field are nearer 1000 to one," he added.

Donnell stressed that while present reserves constitute a 12 to 13 years' supply at current rates of production, this does not mean the nation will be out of oil in a dozen years.

The efficiency of the petroleum transportation system was described by the speaker as one of the factors that enable the industry to sell its gasoline at a lower price today, except for taxes, than it did 30 years ago, even despite inflation. He cited also the rapid technological advance in refining.

Iran Breaks Relations With Britain in Oil Row

Iran's Prime Minister Mohammed Mossadegh officially broke off diplomatic relations with Britain recently because Britain had rejected his demands for $137,200,000 in disputed oil royalties. The entire blame for the oil stalemate was angrily shoved on the British by Mossadegh, who indicated he hoped the break would not be permanent and expressed hope British authorities would "recognize their mistakes" so both nations could cooperate in a friendly atmosphere.

Mossadegh's move means diplomats representing each country will be withdrawn, but the custom allows each nation to name another country to represent its interests.

Two Safety Awards Given

Outstanding safety performances by two departments of The Ohio Oil Company in 1951 have been recognized by the National Safety Council's Award of Honor. The company's production and retail marketing departments both received the award, it was announced by J. C. Askam, Ohio Oil's safety manager.

Shell Development Company has received the Accident Prevention Award of the American Petroleum Institute for establishing a new high of 2,102,120 man-hours worked without a disabling injury. A second certificate was awarded to the company's research division, for 1,439,400 accident-free hours.

NPC Makes Survey of Radio and Radar in Oil

A study is being made of how the oil industry uses radio and radar. The Petroleum Administration for Defense begun a survey to be conducted by the National Petroleum Council, which will take about six months. Idea is to find out how important the various communication systems in the industry are, so that in case of an all-out war the government will know how to handle the industry's demand for equipment.

A committee headed by F. W. Littell of Shell Pipe Line Corporation will made the study.

The industry uses radio most successfully for reporting breaks in the thousands of miles of pipe lines that criss-cross the country. There are more than 300 radio licensees in the oil and gas industry, and about 21,000 radio transmitters now in service.

Radar's most important use is in offshore oil and gas drilling. Companies drilling for oil and gas as far as 18 miles off the Louisiana and Texas coasts have contracted with "weather warning companies," which depend on their radar networks. These electronic devices can gage the height of waves against the offshore derricks and if a heavy storm is building up workers can be warned to come ashore. Radar is also being used in seagoing surveys, to help crewmen establish positions of oil and gas.

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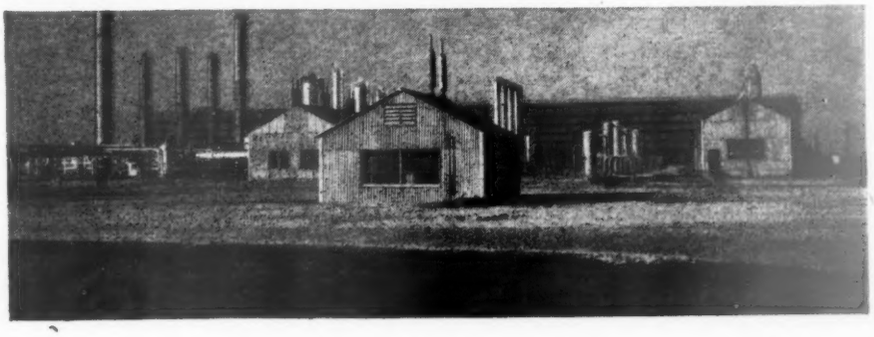

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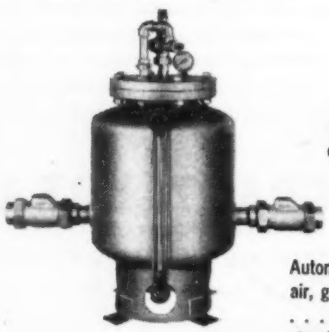

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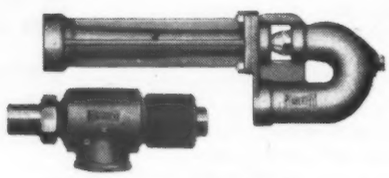

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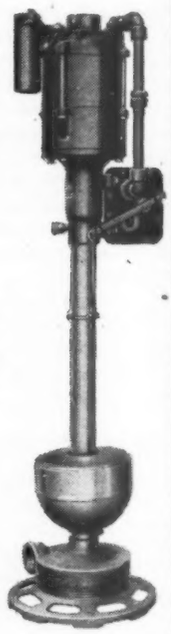

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PAD Issues Additional Steel in Third Quarter

Because production of oil-country tubular goods at some mills since the steel strike has exceeded expectations, the Petroleum Administration for Defense has issued third-quarter authorizations to 157 oil and gas operators for the purchase of an additional 25,000 tons of casing and tubing for delivery during December, Deputy Petroleum Administrator J. Ed Warren announced.

The tonnage is in addition to the approximately 554,000 tons of oil-country tubular goods originally authorized by PAD as primary and supplemental allotments from regular mill production for the third quarter, Warren explained.

A total of 16,505 tons of drill pipe has been allotted to 402 oil and gas operators and drilling contractors for the first quarter of 1953, Warren also announced. At the same time he made public the individual first-quarter allotments.

Warren had earlier reported production of steel tubular goods for oil and gas wells in the fourth quarter of next year should be 16.1 per cent higher than estimated output for the same period this year. Output in the last of 1953 was estimated at 540,000 tons; 75,000 more than is expected in fourth quarter.

Statement of the Ownership, Management, Circulation, etc., Required by the Act of Congress of August 24, 1912, and March 3, 1933, of

THE PETROLEUM ENGINEER

Published monthly at Dallas, Texas, for October 1, 1952.

State of Texas, County of Dallas, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared W. T. Bryan, who, having been duly sworn according to law, deposes and says that he is the Business Manager of

THE PETROLEUM ENGINEER

and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: The Petroleum Engineer Publishing Company, P. O. Box 1589, Dallas, Texas.

Editor: K. C. Sclater, P. O. Box 1589, Dallas, Texas.

Managing Editor: Ernestine Adams, P. O. Box 1589, Dallas, Texas.

Business Manager: W. T. Bryan, P. O. Box 1589, Dallas, Texas.

Advertising Manager: T. J. Crowley, P. O. Box 1589, Dallas, Texas.

Stockholders holding 1 per cent or more of total amount of stock: W. T. Bryan, T. J. Crowley, W. L. Love and K. C. Sclater, all of Dallas, Texas.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustees or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has an interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

W. T. Bryan, Business Manager.

Sworn to and subscribed before me this 29th day of September, 1952.

[Seal] Lillian H. Johnston

(My commission expires June 1, 1953.)

Brown Charges FTC Leftists Let Cartel Charges Out

The Federal Trade Commission has been accused of having "leftists" in its organization who planned the "leaking out" of the "oil cartel" report before members of FTC commissioners had even read it. Bruce K. Brown, president of Pan-Am Southern Corporation, and until recently head of the Petroleum Administration for Defense, charged the preliminary report had been "ostentatiously marked secret" than deliberately circulated to more than 45 Washington bureaus attempting to have data "slip out" to columnists and Congressmen.

He revealed to a group of Tulsa, Oklahoma, business men at a luncheon recently, that he as deputy administrator for PAD had read the report last December and was advised officially by letter no FTC member had ever read it. He said the charges that 5 American oil companies and 2 British companies were parties to a "vicious international cartel to control the oil business of the world" were unsupported by proof.

Since publication of the soft-pedaled report, a grand jury has been called to investigate the charges. More than half its members are Federal Government employees, Brown charged. Brown quoted reports from Venezuela that newspapers there demanded nationalization of the oil industry after the American charges were made.

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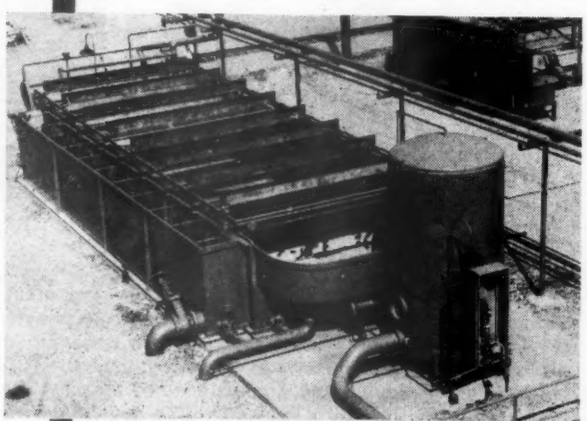
Refinery "C"	232.0	2.0
Oil-field brine "A"	40.0	5.0
Oil-field brine "B"	300 to 500	1.0 to 6.0



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Personals

▸ **J. L. Latimer,** president of Magnolia Petroleum Company and **J. S. Abercrombie,** independent, have been named outstanding industry members for 1952 by the Texas Mid-Continent Oil and Gas Association. They received the association's distinguished service awards at ceremonies as part of the organization's annual meeting in Fort Worth, Texas, recently.

Latimer joined Magnolia 36 years ago as a helper on a loading rack. In 1937 he went to Dallas as assistant general manager of Magnolia Pipeline Company, and in 1946 he became president of Magnolia Petroleum Company.

Abercrombie began roughnecking on the Gulf Coast at the age of 17. In 1920 he purchased a small machine shop in Houston from which he built the Cameron Iron Works. Abercrombie, who is known for his philanthropies, has numerous oil discoveries to his credit.

▸ **Paul E. Taliaferro** has been named executive vice president of Sunray Oil Corporation. He is a director of Sunray and has been a vice president and assistant to the president. He has been with the company since 1931.

H. O. Harder, who since 1949 has been vice president and manager of Sunray's Mid-Continent production division, has been named vice president and manager of Sunray's exploration department, operating in all areas of both the Mid-Continent and California divisions. He joined Sunray in 1945.

R. E. Foss, who since 1951 has been a vice president for Sunray's California division with headquarters in Los Angeles, will move to Tulsa, Oklahoma, to become vice president and manager of the company's exploration department, including drilling and producing activities throughout the Mid-Continent states and California.

H. W. Manley, former vice president and since May, vice president and manager of the company's manufacturing, sales, and pipe line division, will also assume responsibilities for the management of the company's manufacturing, sales, and pipe line activities in California.

In announcing the executive changes incident to a re-alignment of operating responsibility among the officers concerned and which are effective immediately, **Chairman C. H. Wright** and **President W. C. Whaley** said that the new line-up will consolidate executive management of the operating divisions of Sunray Oil Corporation in Tulsa where the general offices are.

▸ **Robert K. Byars** has been promoted to assistant advertising manager of Standard Oil Company. Since 1948 he has been assistant to the advertising manager. He joined Standard in 1946 as advertising and public relations representative in the St. Louis, Missouri, sales field. He was graduated from Washington University with a major in phychology.

Before joining Standard Oil Company Byars was with Stix, Baer, and Fuller department store of St. Louis and Commercial Credit Corporation.

G. W. Orton

▸ **G. W. Orton** has been named resident director of The California Texas Oil Company, Ltd.'s affiliated companies in the United Kingdom. Orton will coordinate the activities of Caltex' affiliated companies in England and will also serve as director on the board of the Regent Oil Company, Ltd.

Orton joined the Caltex group of companies in 1952 after 24 years of experience in the oil industry, having joined The Texas Company in August of 1928 at Houston. After World War II, he was active in the foreign operations of The Texas Company, where he held the position of general manager of foreign operations until shortly before joining Caltex.

He is a graduate of the University of Texas and during World War II served with the Petroleum Administration for War and the War Production Board.

▸ **John Randolph Beverley** has been named to represent International Petroleum Corporation in Lima, Peru, at the International Petroleum Congress in The Hague. Beverley is in charge of personnel for his company.

▸ **Hayes McCoy,** long-time corporate counsel for Cities Service Oil Company (Delaware), has retired. McCoy joined Cities Service in 1916 and served on its legal staff at Bartlesville, Oklahoma, until 1947, when he was named corporate counsel. He is a charter member of the Mid-Continent Oil and Gas Association, has served almost 20 years as member of the General Mid-Continent Oil and Gas Association Legal Committee, the last 15 years as chairman. McCoy is also a charter member of the Osage Oil and Gas Lessees Association, and served as its president for eight years.

▸ **Gustus L. Larson,** emeritus professor of mechanical engineering at the University of Wisconsin, was honored recently for his long years of service to Wisconsin engineering at the annual convention of the Wisconsin Utilities Association. Prof. Larson was cited for his years of service to Wisconsin engineering education and research at a joint luncheon of the gas and electric technical divisions of the association in the Schroeder Hotel, Milwaukee.

▸ **Thomas T. Knight** has been named manager of Sun Oil Company's division order department in that company's Southwest headquarters in Dallas, Texas. He has been first assistant in the department since January, and succeeds the late George McNally. Knight joined Sun in 1946.

▸ **F. B. Jordan, Jr.,** has been elected assistant secretary of the Carter Oil Company, succeeding **H. E. Rogers,** who is retiring after 37 years' service. Jordan is assistant manager of the Carter lease records department, and will be one of three assistant secretaries. Others are J. L. Gill and A. L. Deaton.

Charles A. L. Hogg

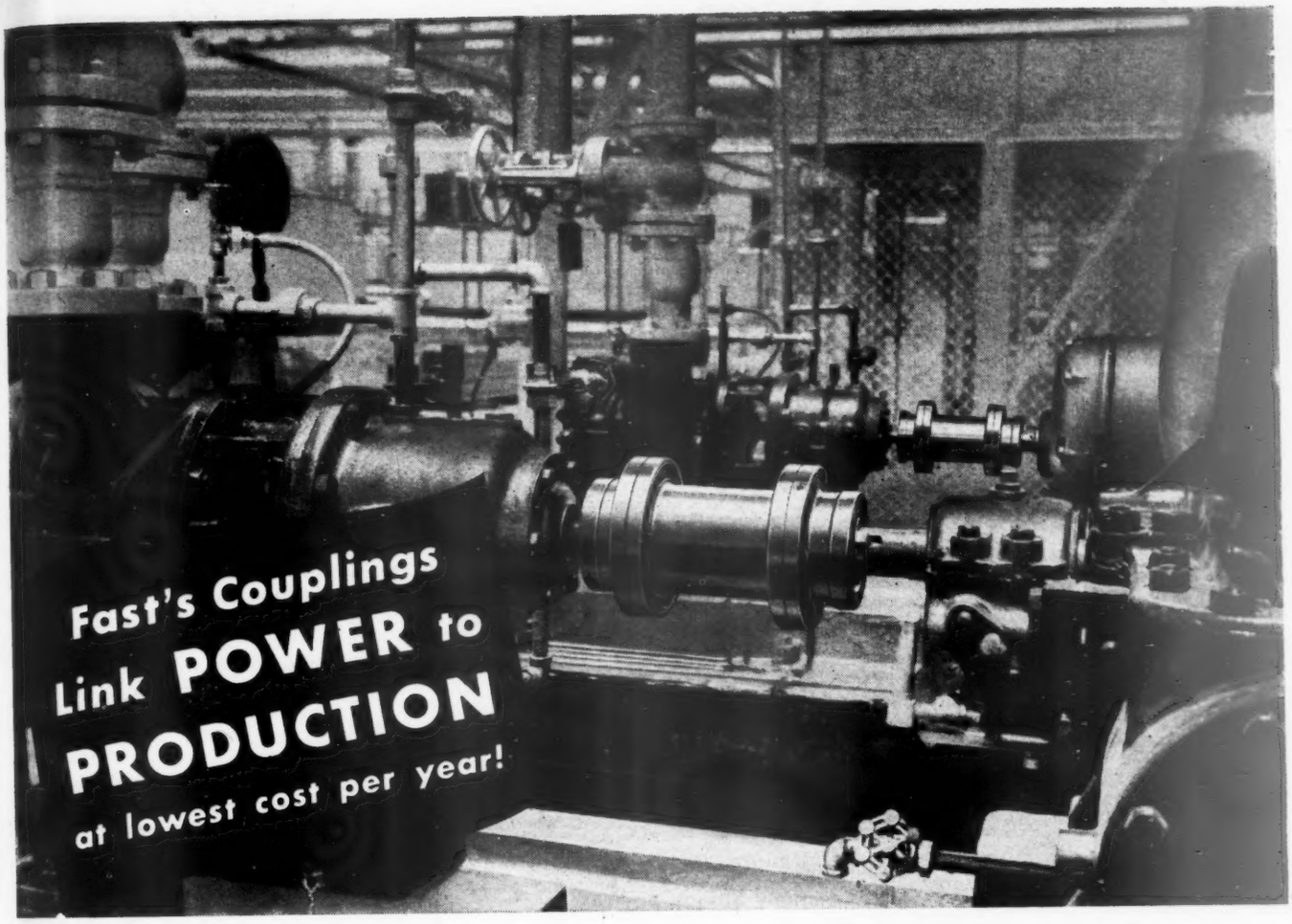
F. H. Edmunds

John W. T. Spinks

▸ **Charles Andrew L. Hogg** has been appointed chairman of the Saskatchewan Oil and Gas Conservation Board, Regina, Saskatchewan. A graduate of the University of Saskatchewan, Hogg joined the Department of Natural Resources of Saskatchewan as geologist in 1944, was promoted to assistant deputy minister, and deputy minister in 1946.

F. H. Edmunds, a member of the Oil and Gas Conservation Board, was graduated from Liverpool University. In 1925 he became assistant professor of soils at the University of Saskatchewan, professor of geology, while carrying out field work for the Provincial Department of Natural Resources and the Dominion Geological Survey, Ottawa.

Third member of the Saskatchewan Oil and Gas Conservation Board is **John William T. Spinks.** A graduate of the University of London, Spinks became professor of chemistry at the University of Saskatchewan in 1930. After extensive study in Canada and Germany and work with the Canadian Air Force, he returned to the University of Saskatchewan in 1945. He served as assistant editor of the Canadian Journal of Research from 1946 to 1952.



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Personals

P. W. Thirtle, vice president of Sinclair Oil Corporation, was recently elected a director of Richfield Oil Corporation. Thirtle has been actively associated in an official capacity with Sinclair Oil and its predecessor companies since 1916.

A. W. Scott, newly elected president of National Petroleum Association, has been appointed to membership on the National Petroleum Council, it was announced by Deputy Petroleum Administrator J. Ed Warren. Scott, who is president of the Wolf's Head Oil Refining Company, Inc., Oil City, Pennsylvania, succeeds **Earle M. Craig**, retiring president of the association.

Harold Vance, head of the petroleum engineering department of Texas A. & M. College, joined the staff of the Second National Bank of Houston, Texas, as head of the oil and gas division. He spent 1½ years as a geologist with United Oil Company in Los Angeles and 1½ years with the U. S. Bureau of Mines in Casper, Wyoming, after graduating from the University of California in 1923.

Vance joined the Marland Oil Company in 1926 as division petroleum engineer, and moved to Midland in 1929 as division superintendent of Continental Oil Company, the successor company to Marland Oil.

Since 1931, Vance has been a consulting engineer and independent operator first in Kilgore, Texas, and, since 1934, at College Station in addition to his duties as Head of the Petroleum Engineering Department of Texas A. & M. College.

Harold Vance

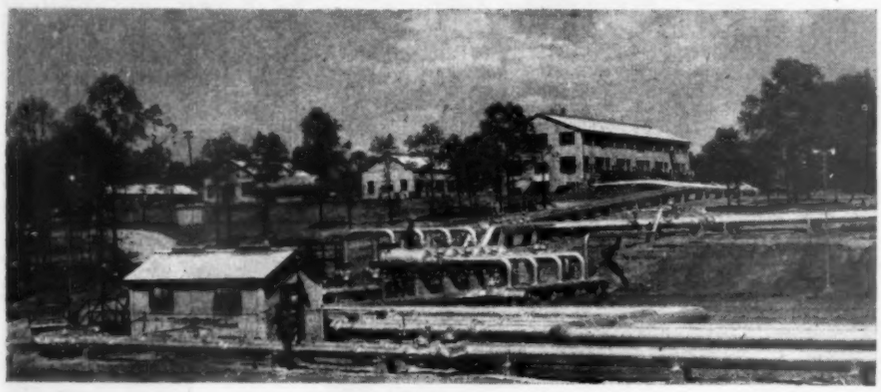
Sir Robert Watson-Watt, British scientist whose pioneer development of radar is credited with having been essential to winning the "Battle of Britain," has assumed office as president of the New Continental Oil Company of Canada, Ltd. Sir Robert was elected as president and as a director at a meeting of the board. He succeeds **Frank Kaftel**, former president and managing director, who has resigned both positions.

New Continental, with large producing properties in Western Canada and Texas, recently has begun research into the use of electronics for oil exploration in an effort to reduce the cost and waste of "dry hole" drillings, and Sir Robert has been advising the company on these matters.

Carl Boucher has been named building manager of the Magnolia Building, Dallas, Texas.

Wilbert M. Nielsen, a senior from Calgary, Alberta, Canada, is the first winner of the newly established $750 Socony-Vacuum Canadian scholarship in petroleum engineering at the University of Oklahoma. Dr. George L. Cross, University president, and C. S. Corbett, Socony-Vacuum Exploration Company, announced the selection for the 1952-1953 school year. The award is the first at O. U. for foreign students financed by the subsidiary or affiliate of a U. S. concern.

Dr. William J. McGill, former assistant general manager of manufacturing of Standard Oil Company (Indiana), has been appointed general manager of industrial and public relations. In this new position at the policy level in the Standard organization Dr. McGill will supervise and co-ordinate the industrial relations and public relations departments.



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DEATHS

Donald H. Lycan, vice president and director of the Signal Oil and Gas Company, died October 14. His passing occurred in Rome, Italy, where he and Mrs. Lycan were on a leisurely European trip, having sailed from San Francisco July 25, 1952. Death resulted from complications following an emergency operation.

Lycan was graduated from Missouri State University in 1910.

In 1930, he became an active member of the Signal Oil and Gas Company organization and for many years has been a director and vice president in charge of the land geological department of the company.

Fred H. Haggerson, chairman of the board of Union Carbide and Carbon Corporation, died in New York City, October 11. Haggerson, who had been with Union Carbide for over 33 years, became chairman of the board in 1951. He had been made vice president of the corporation in 1938, a director in 1941, and president and a member of the executive committee in 1944. He promoted a liberal policy of research and expansion that has been in a large measure responsible for the growth of the corporation.

Donald Adair Powell, vice president and director of the Drilling and Exploration Company, Inc., died October 12 in Hobbs, New Mexico. A colorful figure in the Southwest's oil industry, Powell was in charge of the Panhandle, West Texas, and New Mexico operations at the time of his death. He had held this position since 1936.

Henry M. Dawes, executive committee chairman of Pure Oil Company, died September 29. He was president of Pure Oil for 23 years, before taking his executive board post five years ago. He was comptroller of the currency of the United States in 1923 and 1924, and later became a Federal Reserve Board member. He is a former director of the American Petroleum Institute.

Walter T. Crandall, division superintendent of production for Sinclair Oil and Gas Company, died October 15 in Fort Worth, Texas. A graduate of Marietta College in Ohio, Crandall joined Sinclair 25 years ago. In 1949 he was promoted to assistant division superintendent of production and sent to Midland, Texas, moving back to Fort Worth as division superintendent in 1950.

George L. Machris, one of the most noted petroleum pioneers in the West died recently. He and his two brothers, Victor and Alfred, founded the Wilshire Oil Company, and he was president until his retirement in 1951.

Ernest R. Woodmansee, manager of tool joint sales, Hughes Tool Company, died October 4. A graduate of the University of Michigan, Woodmansee joined Hughes Tool in 1933 and became manager of tool joint sales in 1950. He was formerly with Electrical Engineers' Equipment Company of Illinois.

A. B. Allen, oil field superintendent of the J. J. Lynn Oil Company was killed September 28 in a head-on highway collision. His car collided with a cattle truck near Mineral Wells, Texas.

Lloyd Daniels, partner of the firm of Crawford Drilling Company for several years, died in Laurel, Mississippi, September 25. Daniels had formerly served as drilling superintendent for Crawford's Mississippi operations.

Harold Langdon Gaidry, principal gas engineer for New Orleans public Service, Inc., died September 27 in a New Orleans hospital. He was 54 years old. Gaidry attended Tulane University in New Orleans, where he received his bachelor's degree in engineering in 1923. In 1924, he joined Public Service as an equipment engineer in the railway department. He then moved to a prominent position in the company's gas department, and later was appointed principal gas engineer in the central engineering department.

Frederick L. Curtis, retired vice president of Raybestos-Manhattan, Inc., and former general manager of the Manhattan Rubber Division, died September 20 at his home in Passaic, New Jersey. Curtis was believed to be the oldest pioneer in the American rubber industry, having begun as a shipping room boy with the New York Belting and Packing Company 70 years ago in Sandy Hook, Newtown, Connecticut.

Edward E. Ames, retired chairman of the board, director, vice president, and director of sales, of the General Box Company, died September 28. As president and general manager of his own company, he became interested in the formation of the General Box Company in 1922. From the founding of the company in 1922 he served as vice president and director of sales until his retirement June 30, 1946. Ames was elected chairman of the board of the General Box Company in 1949.

H. A. Mason, assistant to the manager of laboratories with the General Petroleum Corporation, died October 7. Mason had been on leave since January, 1952, for health reasons.

He was a graduate of the University of California, and joined General Petroleum immediately following his graduation as a chemist in 1917. He had been assistant to the manager of laboratories since 1947.

George H. Lang, president and owner of Beacon Drilling Company at Tulsa, Oklahoma, died of a heart attack in his hotel room September 30, while attending the annual meeting of the American Association of Oilwell Drilling Contractors in that city. Lang was a director of AAODC and had been active in that work in the Tulsa area. He was also a director of the API.

Entering the drilling business in 1939, Lang had formerly held prominent positions with Carter Oil Company and Standard Oil Company.

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Beaird-Ingersoll-Rand packaged compressor plants are complete plants, including every component, connection and control required for unattended field operation. They are fully assembled at the factory on rugged steel bases. Sizes range from 110 horsepower to 550 horsepower.

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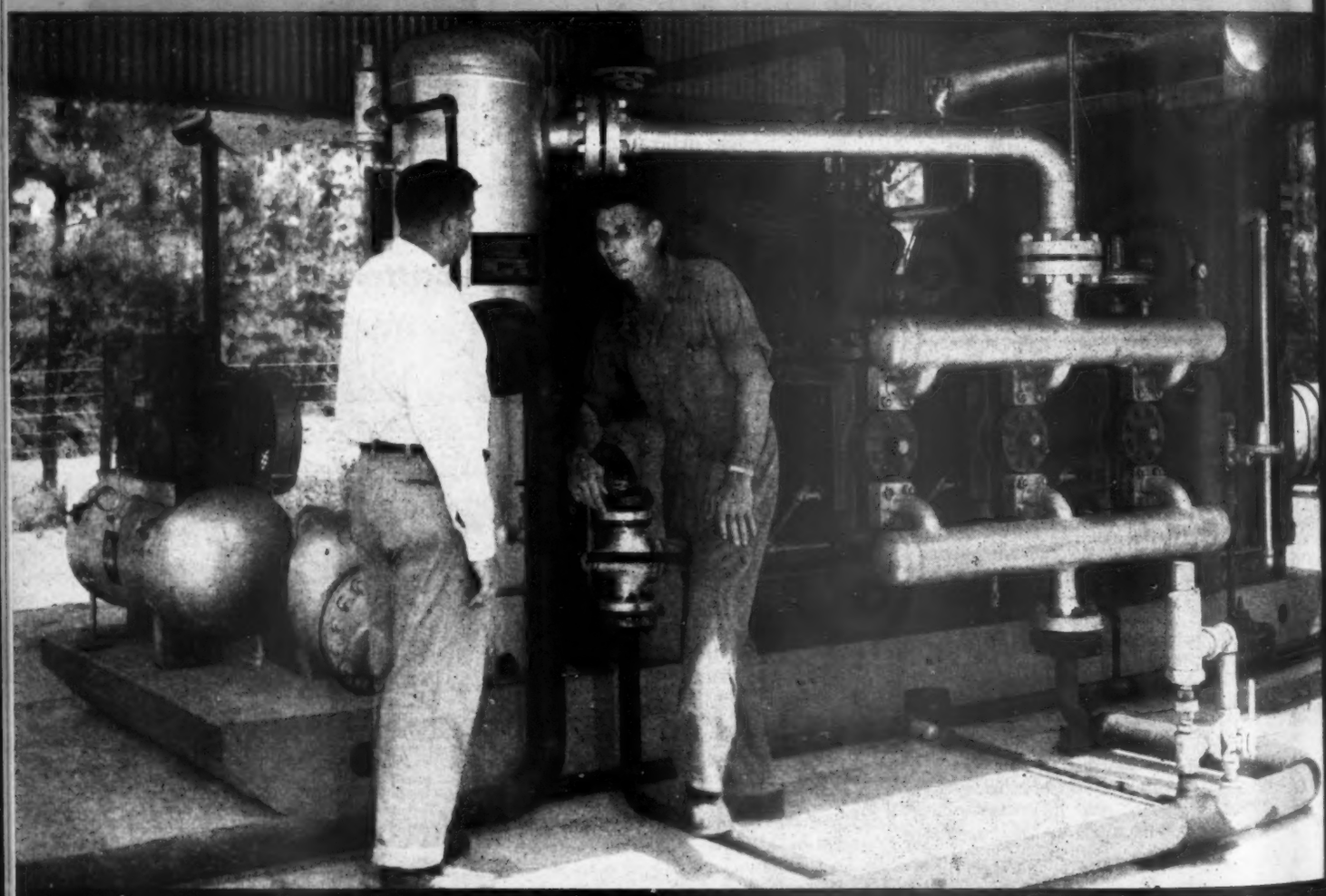

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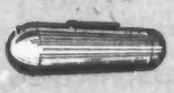

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PRESSURE BULK STORAGE

TON MILES

2⅞-in. drill pipe — 10.4 lb. per foot

15,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	1	1	2	3	3	4	5	5	6
1000	7	7	8	9	10	11	11	12	13	14
2000	15	16	17	18	19	20	21	22	23	24
3000	25	26	27	29	30	31	32	33	35	36
4000	37	38	40	41	42	44	45	46	48	49
5000	51	52	54	55	57	58	60	61	63	65
6000	66	68	69	71	73	75	76	78	80	82
7000	83	85	87	89	91	93	95	96	98	100
8000	102	104	106	108	110	112	114	117	119	121
9000	123	125	127	129	132	134	136	138	141	143
10000	145	148	150	152	155	157	160	162	165	167
11000	170	172	175	177	180	182	185	188	190	193
12000	196	198	201	204	206	209	212	215	218	220
13000	223	226	229	232	235	238	241	244	247	250
14000	253	256	259	262	265	268	271	274	278	281
15000	284	287	290	294	297	300	303	307	310	314
16000	317	320	324	327	331	334	338	341	345	348
17000	352	355	359	363	366	370	373	377	381	384
18000	388	392	396	399	403	407	411	415	419	423
19000	426	430	434	438	442	446	450	454	458	462

20,000 lb EXCESS WEIGHT

0	0	1	2	2	3	4	5	6	7	8
1000	9	9	10	11	12	13	14	15	17	18
2000	19	20	21	22	23	25	26	27	28	30
3000	31	32	33	35	36	38	39	40	42	43
4000	45	46	48	49	51	52	54	55	57	59
5000	60	62	64	65	67	69	70	72	74	76
6000	77	79	81	83	85	87	89	91	93	95
7000	97	99	101	103	105	107	109	111	113	115
8000	117	120	122	124	126	129	131	133	135	138
9000	140	142	145	147	150	152	154	157	159	162
10000	164	167	169	172	175	177	180	182	185	188
11000	190	193	196	199	201	204	207	210	213	215
12000	218	221	224	227	230	233	236	239	242	245
13000	248	251	254	257	260	263	266	270	273	276
14000	279	282	286	289	292	296	299	302	306	309
15000	312	316	319	323	326	330	333	337	340	344
16000	347	351	354	358	362	365	369	373	376	380
17000	384	388	391	395	399	403	407	411	414	418
18000	422	426	430	434	438	442	446	450	454	458
19000	462	467	471	475	479	483	487	492	496	500

25,000 lb EXCESS WEIGHT

0	0	1	2	3	4	5	6	7	8	9
1000	10	12	13	14	15	16	17	19	20	21
2000	23	24	25	27	28	29	31	32	34	35
3000	37	38	40	41	43	44	46	47	49	51
4000	52	54	56	57	59	61	62	64	66	68
5000	70	72	73	75	77	79	81	83	85	87
6000	89	91	93	95	97	99	101	103	106	108
7000	110	112	114	116	119	121	123	126	128	130
8000	133	135	137	140	142	145	147	150	152	155
9000	157	160	162	165	167	170	173	175	178	181
10000	183	186	189	191	194	197	199	203	206	208
11000	211	214	217	220	223	226	229	232	235	238
12000	241	244	247	250	253	257	260	263	266	269
13000	273	276	279	283	286	289	292	296	299	302
14000	306	309	313	316	320	323	327	330	334	337
15000	341	344	348	352	355	359	363	366	370	374
16000	378	381	385	389	393	397	400	404	408	412
17000	416	420	424	428	432	436	440	444	448	452
18000	456	460	465	469	473	477	481	486	490	494
19000	498	503	507	511	516	520	525	529	533	538

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 2⅞-in., 10.4 lb drill pipe and 15,000 lb excess weight = 209.

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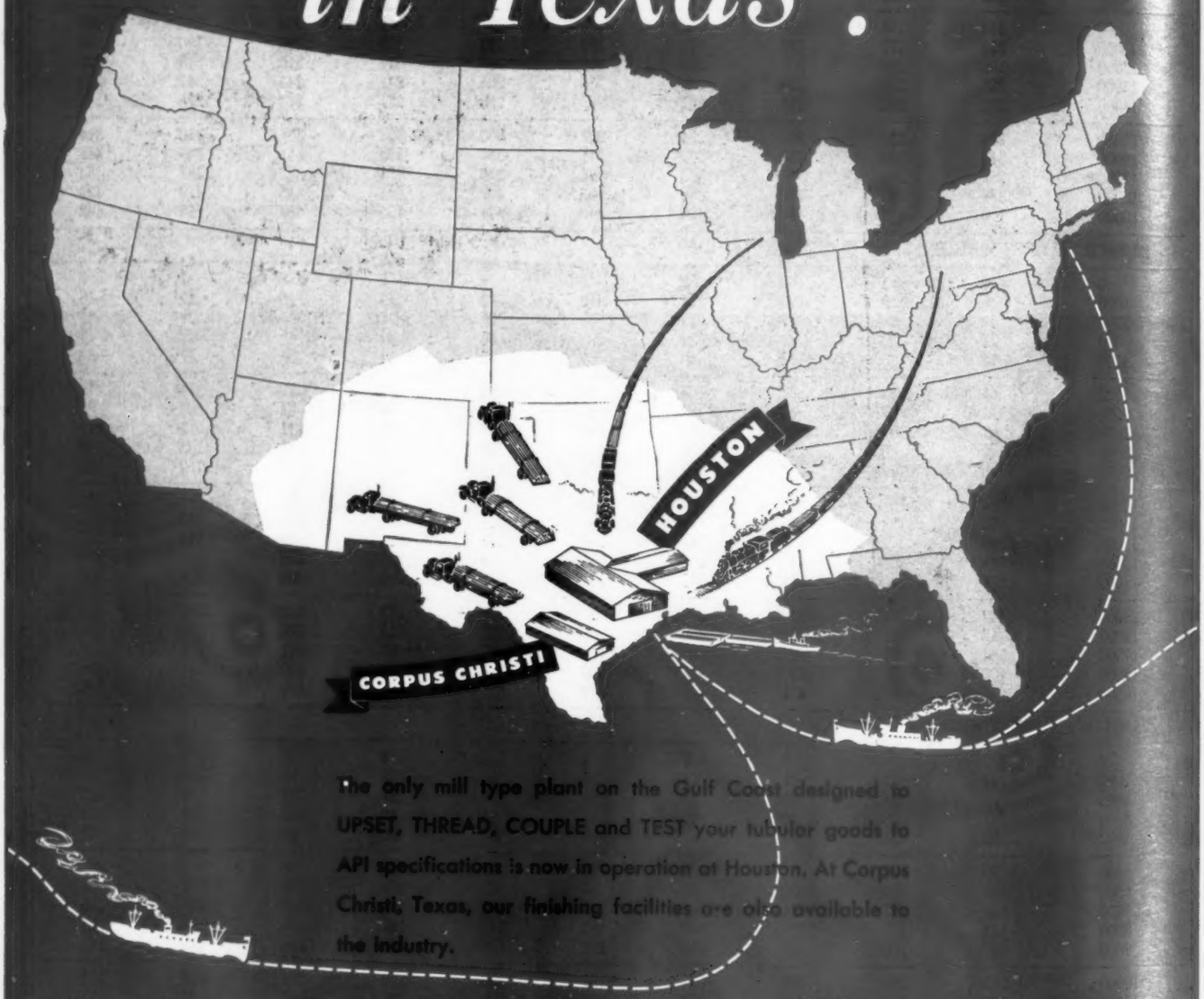

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DEPTH	0	100	200	300	400	500	600	700	800	900
30,000 lb EXCESS WEIGHT										
0	0	1	2	4	5	6	7	9	10	11
1000	12	14	15	16	18	19	20	22	23	25
2000	26	28	29	31	32	34	36	37	39	41
3000	42	44	46	47	49	51	53	54	56	58
4000	60	62	64	65	67	69	71	73	75	77
5000	79	81	83	85	87	89	92	94	96	98
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8000	148	150	153	155	158	161	163	166	169	171
9000	174	177	180	182	185	188	191	194	196	199
10000	202	205	208	211	214	217	220	223	226	229
11000	232	235	238	241	245	248	251	254	257	261
12000	264	267	270	274	277	280	284	287	290	294
13000	297	301	304	308	311	314	318	322	325	329
14000	332	336	340	343	347	351	354	358	362	366
15000	369	373	377	381	384	388	392	396	400	404
16000	408	412	416	420	424	428	432	436	440	444
17000	448	452	457	461	465	469	473	478	482	486
18000	490	495	499	503	508	512	517	521	526	530
19000	534	539	543	548	552	557	562	566	571	575
35,000 lb EXCESS WEIGHT										
0	0	1	3	4	6	7	9	10	11	13
1000	14	16	17	19	20	22	24	25	27	29
2000	30	32	34	35	37	39	41	42	44	46
3000	48	50	52	54	56	57	59	61	63	65
4000	67	69	72	74	76	78	80	82	84	86
5000	89	91	93	95	98	100	102	105	107	109
6000	112	114	116	119	121	124	126	129	131	134
7000	136	139	142	144	147	149	152	155	157	160
8000	163	166	168	171	174	177	180	183	185	188
9000	191	194	197	200	203	206	209	212	215	218
10000	221	224	227	231	234	237	240	243	246	250
11000	253	256	260	263	266	270	273	276	280	283
12000	286	290	293	297	300	304	307	311	315	318
13000	322	325	329	333	336	340	344	348	351	355
14000	359	363	366	370	374	378	382	386	390	394
15000	398	402	406	410	414	418	422	426	430	434
16000	438	442	446	451	455	459	463	468	472	476
17000	481	485	489	494	498	502	507	511	516	520
18000	525	529	534	538	543	547	552	557	561	566
19000	570	575	580	585	589	594	599	604	608	613
40,000 lb EXCESS WEIGHT										
0	0	2	3	5	6	8	10	11	13	15
1000	16	18	19	21	23	25	27	28	30	32
2000	34	36	38	40	42	44	46	48	50	52
3000	54	56	58	60	62	64	66	68	71	73
4000	75	77	79	82	84	86	89	91	93	96
5000	98	101	103	105	108	110	113	115	118	120
6000	123	125	128	131	133	136	139	141	144	147
7000	150	152	155	158	161	164	167	169	172	175
8000	178	181	184	187	190	193	196	199	202	205
9000	208	211	214	218	221	224	227	230	234	237
10000	240	243	247	250	253	256	260	264	267	270
11000	274	277	281	284	288	291	295	298	302	306
12000	309	313	317	320	324	328	331	335	339	343
13000	346	350	354	358	362	366	370	373	377	381
14000	385	389	393	397	401	406	410	414	418	422
15000	426	430	434	439	443	447	451	456	460	464
16000	469	473	477	482	486	490	495	499	504	508
17000	513	517	522	526	531	536	540	545	549	554
18000	559	563	568	573	578	582	587	592	597	602
19000	606	611	616	621	626	631	636	641	646	651

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 2⅞-in., 10.4 lb drill pipe and 30,000 lb excess weight = 280.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

Not Such A Tough Decision!

It wouldn't take one of our salesmen five minutes to make his choice in a case like this, and *the customer always wins.* We've built our business on *service* and we think it's a good idea. Yes sir! When it comes to getting your oil and gas supplies to you on time and delivered where you want them, we let nothing stand in our way.

Our Stores and Offices are Located in:

- **Shreveport, La.**
- **Baton Rouge, La.**
- **Lafayette, La.**
- **West Point, Miss.**
- **Yazoo City, Miss.**
- **Tinsley, Miss.**
- **Camden, Ark.**
- **Magnolia, Ark.**
- **Tulsa, Okla.**
- **Dallas, Texas**
- **Abilene, Texas**
- **Midland, Texas**
- **Houston, Texas**
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New York Office — Room 1212, 502 Park Avenue — Telephone El Dorado 5-3572

Chicago Representative — Telephone Midway 3-6172

SUPERIOR

IRON WORKS & SUPPLY COMPANY, INC.

1202-04 MARSHALL STREET • P. O. BOX 1800 • SHREVEPORT, LA.

TON MILES

2⅞-in. drill pipe — 10.4 lb. per foot

45,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	4	5	7	9	11	13	14	16
1000	18	20	22	24	26	28	30	32	34	36
2000	38	40	42	44	46	48	50	53	55	57
3000	59	62	64	66	68	71	73	75	78	80
4000	83	85	87	90	92	95	97	100	103	105
5000	108	110	113	115	118	121	123	126	129	132
6000	134	137	140	143	146	148	151	154	157	160
7000	163	166	169	172	175	178	181	184	187	190
8000	193	196	200	203	206	209	212	215	219	222
9000	225	229	232	235	238	241	245	249	252	256
10000	259	263	266	270	273	276	280	284	287	291
11000	295	298	302	306	309	313	317	321	324	328
12000	332	336	340	344	348	351	355	360	363	367
13000	371	375	379	383	387	391	395	400	404	408
14000	412	416	420	425	429	433	437	442	446	450
15000	455	459	463	468	472	477	481	485	490	494
16000	499	503	508	513	517	522	526	531	536	540
17000	545	550	554	560	564	569	574	578	583	588
18000	593	598	603	608	613	617	622	627	632	637
19000	642	648	653	658	663	668	673	678	683	689

50,000 lb EXCESS WEIGHT

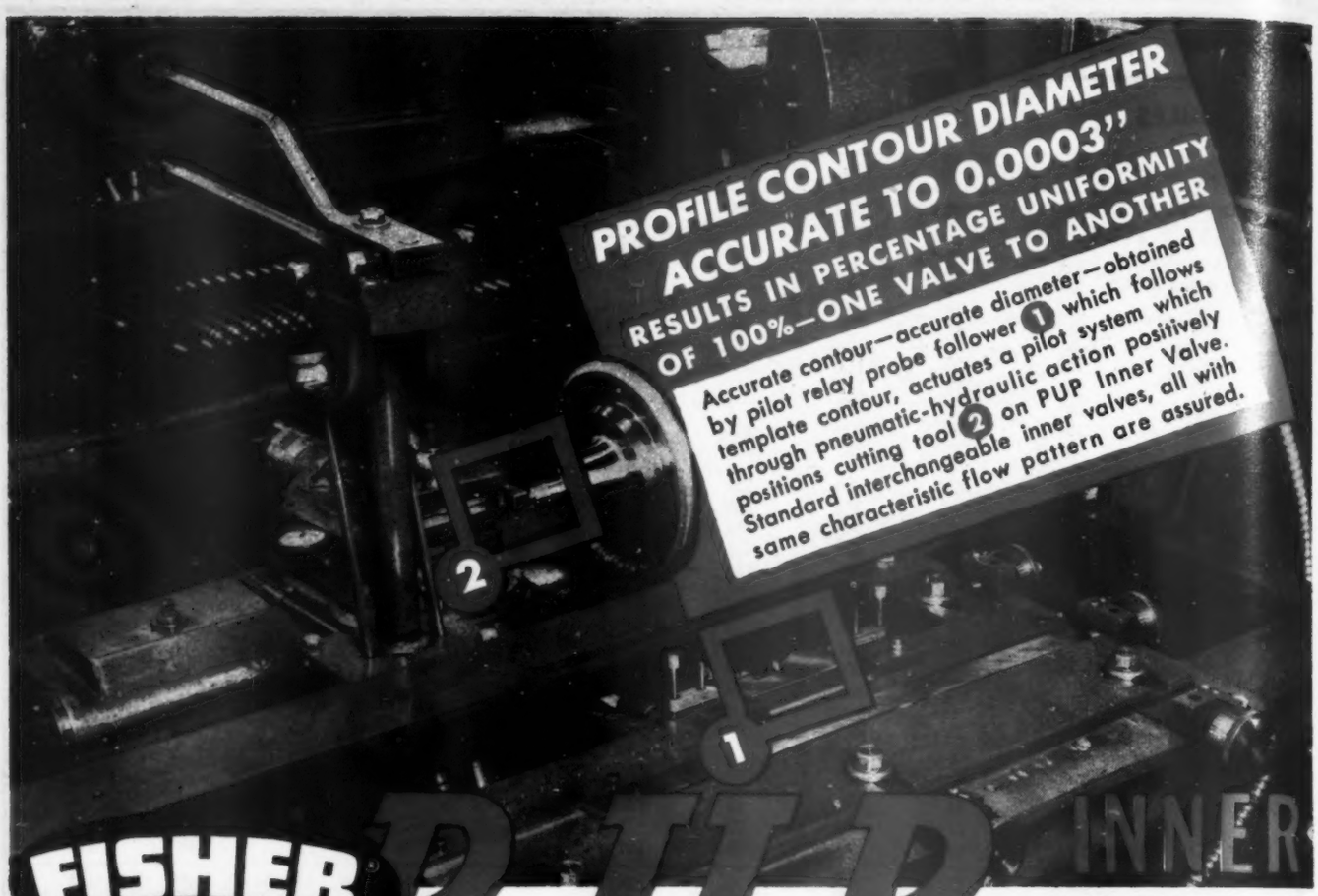
0	0	2	4	6	8	10	12	14	16	18
1000	20	22	24	26	28	30	33	35	37	39
2000	42	44	46	48	51	53	55	58	60	63
3000	65	67	70	72	75	77	80	82	85	88
4000	90	93	95	98	101	104	106	109	112	114
5000	117	120	123	125	128	131	134	137	140	143
6000	146	149	152	155	158	161	164	167	170	173
7000	176	179	182	186	189	192	195	199	202	205
8000	208	212	215	218	222	225	229	232	235	239
9000	242	246	249	253	256	260	263	267	271	274
10000	278	282	285	289	293	297	300	304	308	312
11000	316	319	323	327	331	335	339	343	347	351
12000	355	359	363	367	371	375	379	383	387	392
13000	396	400	404	408	413	416	421	425	430	434
14000	438	443	447	452	456	461	465	469	474	479
15000	483	487	492	497	501	506	510	515	520	525
16000	529	534	539	543	548	553	558	563	568	573
17000	577	582	587	592	597	602	607	612	617	622
18000	627	632	637	642	647	653	658	663	668	673
19000	679	684	689	694	700	705	710	716	721	726

55,000 lb EXCESS WEIGHT

0	0	2	4	7	9	11	13	15	18	20
1000	22	24	26	29	31	33	36	38	40	43
2000	45	48	50	53	55	58	60	63	66	68
3000	71	73	76	79	81	84	87	89	92	95
4000	98	101	103	106	109	112	115	118	121	124
5000	127	130	133	136	139	142	145	148	151	154
6000	157	160	163	167	170	173	176	180	183	186
7000	189	193	196	199	203	206	210	213	217	220
8000	224	227	231	234	238	241	245	249	252	256
9000	259	263	267	271	274	278	282	286	289	293
10000	297	301	305	309	313	317	321	324	328	332
11000	337	340	345	348	353	357	361	365	369	373
12000	377	382	386	390	394	398	403	407	412	416
13000	420	425	429	434	438	442	447	451	456	460
14000	465	470	474	479	483	488	493	497	502	507
15000	511	516	521	526	530	535	540	545	550	555
16000	560	564	569	574	579	584	589	589	599	604
17000	609	614	620	625	630	635	640	645	651	656
18000	661	666	672	677	682	688	693	698	704	709
19000	715	720	725	731	736	742	747	753	758	764

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 2⅞-in., 10.4 lb drill pipe and 45,000 lb excess weight = 351.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation


PROFILE CONTOUR DIAMETER
ACCURATE TO 0.0003"
RESULTS IN PERCENTAGE UNIFORMITY
OF 100%—ONE VALVE TO ANOTHER
Accurate contour—accurate diameter—obtained by pilot relay probe follower 1 which follows template contour, actuates a pilot system which through pneumatic-hydraulic action positively positions cutting tool 2 on PUP Inner Valve. Standard interchangeable inner valves, all with same characteristic flow pattern are assured.
2
1

FISHER PUP INNER VALVES

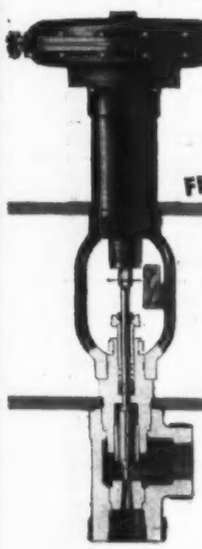
PRESSURE UNIFORM PERCENTAGE

PRECISION MANUFACTURED FOR ASSURED PERFORMANCE

40 TO 1 RANGEABILITY

STAINLESS STEEL OR CAST STELLITE

EQUAL PERCENTAGE FLOW CHARACTERISTICS



Type 57T-DA direct acting diaphragm motor valve showing Micro-Form Pup in Fisher high pressure cast steel Design "D" angle body.

6 Years Old—Now Grand Champions

Excellent acceptance, phenomenal service and extremely satisfactory performance—that's the 6 year record of FISHER PUP INNER VALVES.

Available in two types, Micro-Flute and Micro-Form. Sizes ¼" to 1". Applicable to control valve sizes 1" to 2"

FISHER GOVERNOR COMPANY • MARSHALLTOWN, IOWA

LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE CONTROL

PUMP EQUIVALENTS — GAL. PER MINUTE

Gal. per minute	Gal. per hour	Gal. per day*	Cu. ft. per second	Cu. ft. per minute	Cu. ft. per hour	Cu. ft. per day*	†Bbl. per minute	Bbl. per hour	Bbl. per day*
10	600	14,400		1.337	80.22	1925.3	0.24	14.28	342.9
12	720	17,280		1.604	96.26	2310.3	0.29	17.15	411.4
14	840	20,160		1.872	112.3	2695.4	0.33	20.00	480.0
16	960	23,040		2.139	128.4	3080.4	0.38	22.86	548.6
18	1,080	25,920		2.407	144.4	3465.5	0.43	25.72	617.1
20	1,200	28,800		2.674	164.4	3850.6	0.48	28.58	685.7
22	1,320	31,680		2.941	176.5	4235.7	0.52	31.44	685.7
24	1,440	34,560		3.208	192.5	4620.7	0.57	34.29	822.9
26	1,560	37,440		3.476	208.6	5005.8	0.62	37.15	891.4
28	1,680	40,320		3.744	224.6	5390.8	0.67	40.01	960.0
30	1,800	43,200		4.001	240.7	5775.9	0.71	42.87	1028.6
32	1,920	36,080		4.278	256.7	6160.9	0.76	45.73	1097.2
34	2,040	48,960		4.546	272.7	6546.0	0.81	48.59	1165.7
36	2,160	51,840		4.813	288.8	6931.1	0.86	51.44	1234.3
38	2,280	54,720		5.081	304.8	7316.1	0.90	54.30	1302.9
40	2,400	57,600		5.348	320.9	7701.2	0.95	57.16	1371.4
45	2,700	64,800	0.10	6.016	360.9	8663.8	1.07	64.31	1542.9
50	3,000	72,000		6.685	401.1	9626.5	1.19	71.45	1714.3
55	3,300	79,200		7.354	441.2	10,589	1.31	78.59	1885.7
60	3,600	86,400		8.022	481.3	11,552	1.43	85.74	2057.2
65	3,900	93,600		8.691	521.4	12,514	1.55	92.89	2228.6
70	4,200	100,800		9.359	561.5	13,477	1.66	100.0	2400.0
75	4,500	108,000		10.03	601.7	14,439	1.78	107.1	2571.5
80	4,800	115,200		10.69	641.8	15,402	1.90	114.3	2742.9
85	5,100	122,400		11.36	681.9	16,365	2.02	121.5	2914.3
90	5,400	129,600	0.20	12.03	721.9	17,328	2.14	128.6	3085.7
95	5,700	136,800		12.70	762.1	18,290	2.26	135.8	3257.2
100	6,000	144,000		13.37	802.2	19,253	2.40	142.9	3428.6
105	6,300	151,200		14.04	842.3	20,216	2.49	150.0	3600.0
110	6,600	158,400		14.71	882.4	21,178	2.62	157.2	3771.5
115	6,900	165,700		15.38	922.5	22,141	2.74	164.3	3942.9
120	7,200	172,800		16.04	962.6	23,104	2.86	171.5	4114.3
125	7,500	180,000		16.71	1002.7	24,066	2.98	178.6	4285.8
130	7,800	187,200		17.38	1042.8	25,029	3.09	185.8	4457.2
135	8,100	194,400	0.30	18.05	1082.9	25,992	3.21	192.9	4628.6
140	8,400	201,600		18.72	1123.1	26,954	3.33	200.1	4800.0
145	8,700	208,800		19.39	1163.2	27,917	3.45	207.2	4971.5
150	9,000	216,000		20.05	1203.3	28,879	3.57	214.3	5142.9
155	9,300	223,200		20.72	1243.4	29,842	3.69	221.5	5314.3
160	9,600	230,400		21.39	1283.5	30,805	3.81	228.6	5485.8
165	9,900	237,600		22.06	1323.6	31,767	3.93	235.8	5657.2
170	10,200	244,800		22.72	1363.7	32,730	4.05	242.9	5828.6
175	10,500	252,000		23.39	1403.8	33,693	4.16	250.0	6000.0
180	10,800	259,200	0.40	24.06	1443.9	34,655	4.28	257.2	6171.5
185	11,100	252,000		24.73	1484.1	35,618	4.40	264.4	6342.9
190	11,400	273,600		25.40	1524.2	36,581	4.52	271.5	6514.3
195	11,700	280,800		26.07	1564.3	37,543	4.64	278.7	6685.8

*24 hr. day.

†42 gal. bbl.

SAVE TIME TWO WAYS

with TOLEDO SIMPACT

for all 1" to 2" threading!

Dies changed from one size to another in a few seconds. Positive, practical die setting.

QUICK CHANGE TO 4 PIPE SIZES

QUICK THREADING

ONLY ONE SET OF DIES for 4 pipe sizes.

FASTER CHANGE OF SIZES! Just push the size selector button, slip dies in proper steps, turn head slightly and die size is changed!

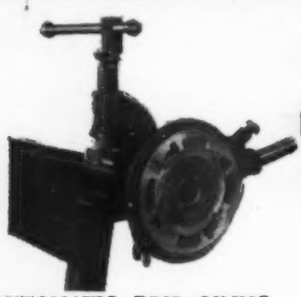
EXTRA RUGGED FOR EXTRA LONG LIFE . . . producing accurate threads.

EASY TO OPERATE . . . simple in design . . . fewer parts . . . light in weight.

AMAZINGLY COMPACT . . . will thread a pipe projecting through a wall as short as 6¼".

ACCURACY THROUGH THE YEARS . . . dies recede along tapered steps . . . no cams to wear.

LOW COST! This remarkable self-contained tool assures smooth, perfectly tapered, leak-proof threads at lower cost! Play safe! Buy Toledo Simpacts at your dealer. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.



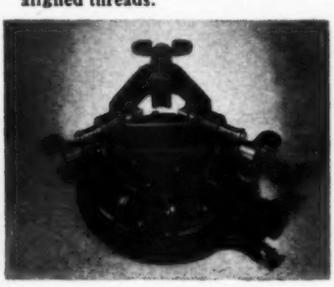
50 YEARS OF LEADERSHIP

TOLEDO

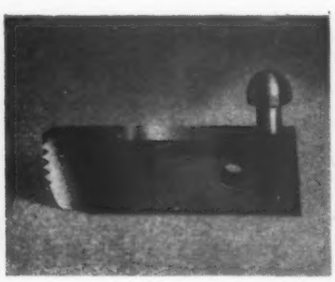
PIPE TOOLS . . . POWER DRIVES . . . POWER PIPE MACHINES

AUTOMATIC DRIP OILING. Oil pockets in head of a Simpact collect oil and drip directly on dies.

3-CHUCK JAWS. Simpact pipe holder with 3-chuck jaws is easy to center, and assures perfect aligned threads.



TOLEDO SIMPACT DIES are made of high speed steel and are easily resharpened.

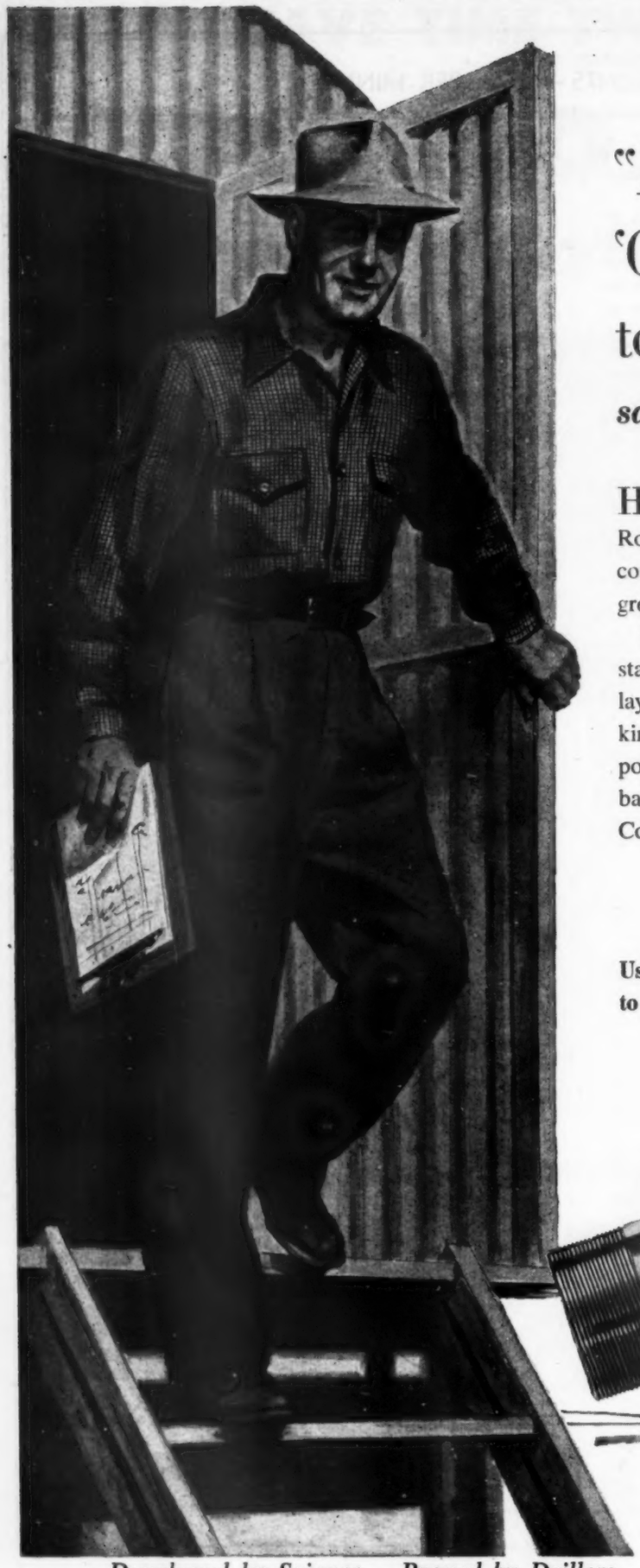


SIMPLE . . . COMPACT. Note the simplicity of the Simpact. No complicated cam parts to clog with dirt and wear.

PUMP EQUIVALENTS — GAL. PER MINUTE

Gal. per minute	Gal. per hour	Gal. per day*	Cu. ft. per second	Cu. ft. per minute	Cu. ft. per hour	Cu. ft. per day*	†Bbl. per minute	Bbl. per hour	Bbl. per day*
200	12,00	288,000		26.67	1600	38,400	4.76	285	6,857
205	12,300	295,200		27.33	1640	39,360	4.88	293	7,028
210	12,600	302,400		28.00	1680	40,320	5.00	300	7,199
215	12,900	309,600		28.66	1720	41,280	5.12	307	7,371
220	13,200	316,800		29.33	1760	42,240	5.24	315	7,543
225	13,500	324,000	0.50	30.00	1800	43,200	5.36	322	7,714
230	13,800	331,200		30.67	1840	44,160	5.48	329	7,885
235	14,100	338,400		31.33	1880	45,120	5.59	336	8,056
240	14,400	345,600		32.00	1920	46,080	5.71	343	8,228
245	14,700	352,800		32.67	1960	47,040	5.83	350	8,399
250	15,000	360,000		33.34	2000	48,000	5.95	358	8,571
255	15,300	367,200		34.00	2040	48,960	6.07	365	8,742
260	15,600	374,400		34.67	2080	49,920	6.19	371	8,914
265	15,900	381,600		35.34	2120	50,880	6.31	378	9,085
270	16,200	388,800	0.60	36.00	2160	51,840	.43	386	9,256
275	16,500	396,000		36.67	2200	,800	.55	393	9,428
280	16,800	403,200		37.34	2240	53,760	6.67	400	9,599
285	17,100	410,400		38.00	2280	54,720	6.78	407	9,771
290	17,400	417,600		38.67	2320	55,680	6.90	414	9,942
295	17,700	424,800		39.34	2360	56,640	7.02	421	10,114
300	18,000	432,000		40.00	2400	57,600	7.14	429	10,285
305	18,300	439,200		40.67	2440	58,560	7.26	436	10,456
310	18,600	446,400		41.34	2480	59,520	7.38	443	10,628
315	18,900	453,600	0.70	42.00	2520	60,480	7.50	450	10,799
320	19,200	460,800		42.67	2560	61,640	7.62	457	10,971
325	19,500	468,000		43.34	2600	62,400	7.74	464	11,142
330	19,800	475,200		44.00	2640	63,360	7.86	471	11,314
335	20,100	482,400		44.67	2680	64,320	7.98	479	11,485
340	20,400	489,600		45.34	2720	65,280	8.09	486	11,656
345	20,700	496,800		46.00	2760	66,240	8.21	493	11,828
350	21,00	504,000		46.67	2800	67,200	8.33	500	11,999
355	21,300	511,200		47.34	2840	68,160	8.45	507	12,171
360	21,600	518,400	0.80	48.00	2880	69,120	8.57	514	12,342
365	21,900	525,600		48.67	2920	70,080	8.69	521	12,514
370	22,200	532,800		49.34	2960	71,040	8.81	529	12,685
375	22,500	540,000		50.00	3000	72,000	8.93	536	12,856
380	22,800	547,200		50.67	3040	72,960	9.05	543	13,028
385	23,100	554,400		51.34	3080	73,920	9.17	550	13,199
390	23,400	561,600		52.00	3120	74,880	9.29	557	13,371
395	23,700	568,800		52.67	3160	75,840	9.40	564	13,542
400	24,000	576,000	0.90	53.34	3200	76,800	9.52	572	13,714
405	24,300	583,200		54.00	3240	77,760	9.64	579	13,885
410	24,600	590,400		54.67	3280	78,720	9.76	586	14,056
415	24,900	597,600		55.34	3320	79,680	9.88	593	14,228
420	25,200	604,800		56.00	3360	80,640	10.0	600	14,399
425	25,500	612,000		56.67	3400	81,600	10.1	607	14,571
430	25,800	619,200		57.34	3440	82,560	10.2	614	14,742
435	26,100	626,400		58.00	3480	83,520	10.4	622	14,914
440	26,400	633,600		58.67	3520	84,480	10.5	629	15,085
445	26,700	640,800		59.34	3560	85,440	10.6	636	15,257

*24 hr. day
†42 gal. bbl.



"Anywhere in the 'Oil Patch' we stick to U. S. Royal 4,"

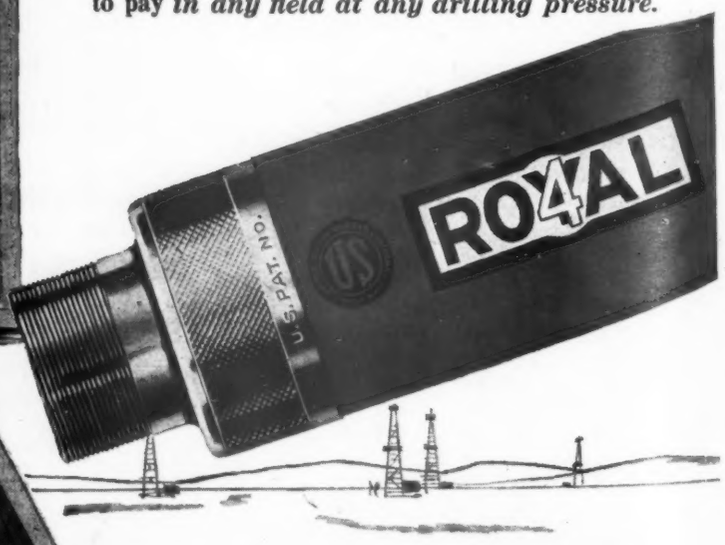
says "Red" Royal

He has his good reasons. He knows that U. S. Royal 4 Rotary Hose eliminates delays, avoids costly down time. That's why you can't beat this great hose for economy.

U. S. Royal 4 is the perfect hose for any rig—standard or portable—it's flexible. Two double wire layers—*actually two hose in one*—resist excessive kinking and straining on narrow base rigs of the portable type. It also has the burst strength to combat the highest pressures found in the deepest Gulf Coast wells.

Available in all FIELDS at the BEST SUPPLY STORES

Use U. S. Royal 4 all the way... use it from spud to pay *in any field at any drilling pressure.*



Developed by Science... Proved by Drillers

PRODUCT OF U.S. RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

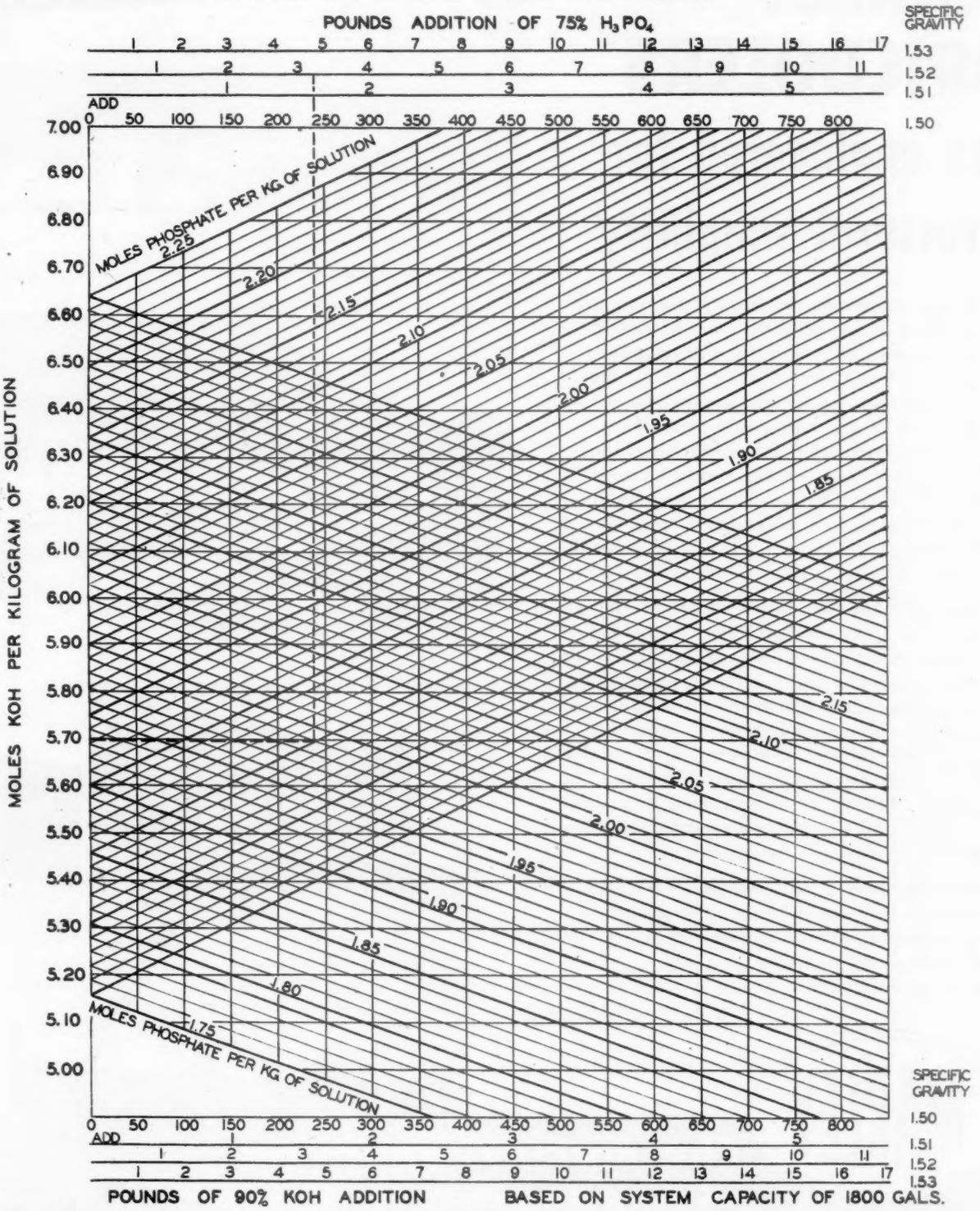
MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

HYDROGEN SULPHIDE REMOVAL BY POTASSIUM PHOSPHATE SOLUTION

Many refineries and other plants processing hydrocarbons use potassium phosphate for removal of hydrogen sulphide. When the spent solution is regenerated, an analysis is made to determine the concentrations of potassium ion and of phosphate ion. Calculations can then be made, based on the capacity of the system and the specific gravity, to find the proper weight of either component that must be added to restore the original equilibrium between K^+ ions and $PO_4^{\equiv}$ ions at the optimum ratio of $\frac{K^+}{PO_4^{\equiv}} = 2.95$.

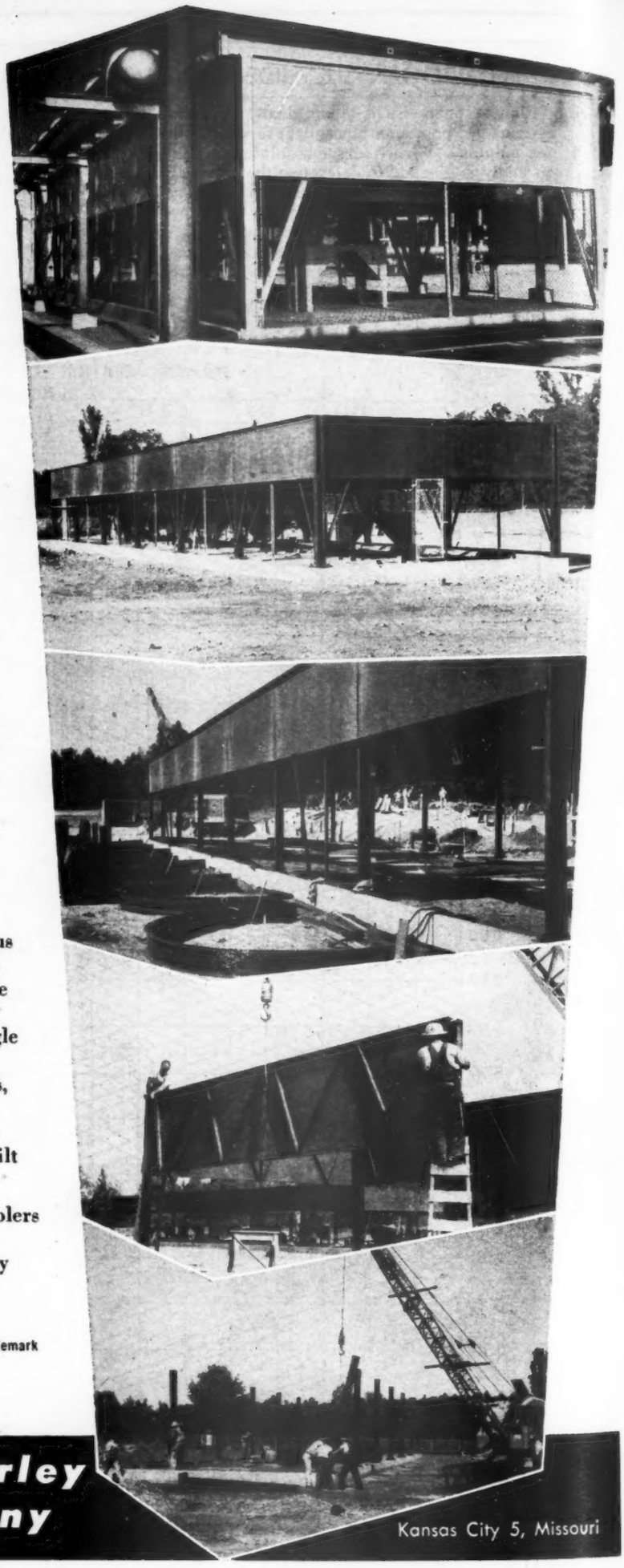
The chart below is intended only to be an aid in rapid computation of the required chemical addition after the analysis has been completed.

Example: Analysis of the regenerated solution shows the potassium ion concentration to be 5.70 moles per kilogram, the phosphate ion concentration 1.85 moles per kilogram, and the specific gravity 1.52. *Solution:* As indicated by the dotted lines on the chart, 243 pounds of 75 per cent phosphoric acid must be added to restore the ratio of 2.95. This is based on a system capacity of 1800 gal., but a conversion factor would adapt it to systems of other capacities.



from the ground up,

MARLEY DRICOOLERS* are engineered for structural simplicity



Marley engineers designed DriCooler air-cooled heat exchanges with two objectives constantly in mind: stability and simplicity. That's why DriCoolers operate without the "shock and rock, quake and quiver" vibration often found in this type equipment. That's why field construction is no high-cost, long-time project. Every strong, sturdy element of the excellent DriCooler structure is completely prefabricated to facilitate erection. DriCoolers go up fast . . . and once erected stay there for long years of service.

This strength and simplicity are Marley plus values. The ability of DriCoolers to cool fluids and gases efficiently and economically is the primary reason for their selection by industry after industry. Flexibility of design for single or multiple service, and the wide range of sizes in *both* induced and forced draft models, fit DriCoolers to every industrial cooling operation. All are, of course, equipped with fans, drives and Geareducers designed and built by Marley exclusively for cooling service.

The engineering skill that produces DriCoolers is available to assist in their application to every type of installation. Just call the Marley man in your city or write Dept. DC . . . there is no obligation.

*Reg. Trademark

MARLEY

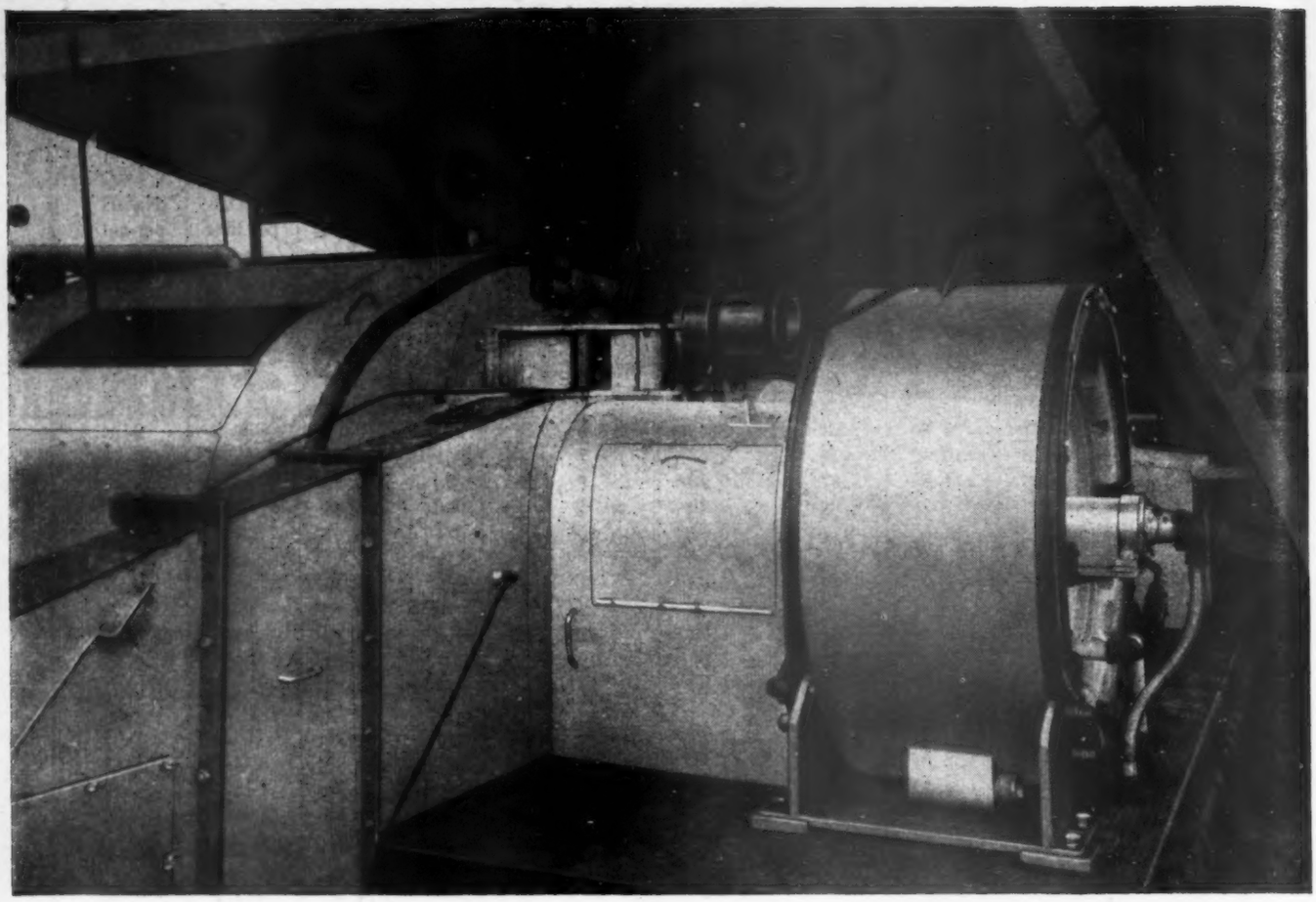
The Marley Company

Kansas City 5, Missouri

DENSITY AND CAUSTIC CONTENT OF CAUSTIC SODA SOLUTIONS
(15°C or 59°F)

Weight percent of NaOH	Sp. gr.	Gravity, deg. Bé.	Grams NaOH per liter	Lb NaOH per gal.	Gravity, deg. Bé.	Sp. gr.	Weight percent of NaOH	Grams NaOH per liter	Lb. NaOH per gal.
1	1.011	1.53	10.1	0.08	1	1.007	0.68	6.8	0.06
2	1.022	3.12	20.4	0.17	2	1.014	1.30	13.2	0.11
3	1.033	4.66	31.0	0.26	3	1.021	1.92	19.6	0.16
4	1.044	6.17	41.8	0.35	4	1.028	2.57	26.4	0.22
5	1.056	7.63	52.8	0.44	5	1.036	3.22	33.4	0.28
6	1.067	9.06	64.0	0.53	6	1.043	3.89	40.6	0.34
7	1.078	10.46	75.4	0.63	7	1.051	4.57	48.0	0.40
8	1.089	11.83	87.1	0.73	8	1.058	5.26	55.7	0.46
9	1.100	13.18	99.0	0.83	9	1.066	5.96	63.5	0.53
10	1.111	14.50	111.1	0.93	10	1.074	6.67	71.6	0.60
11	1.122	15.79	123.4	1.03	11	1.082	7.39	80.0	0.67
12	1.133	17.05	136.0	1.13	12	1.090	8.12	88.5	0.74
13	1.144	18.29	148.7	1.24	13	1.098	8.87	97.4	0.81
14	1.155	19.51	161.8	1.35	14	1.107	9.62	106.5	0.89
15	1.167	20.70	175.1	1.46	15	1.115	10.39	115.8	0.97
16	1.178	21.87	188.4	1.57	16	1.124	11.16	125.4	1.05
17	1.189	23.01	202.1	1.69	17	1.133	11.96	135.5	1.13
18	1.200	24.14	216.0	1.80	18	1.142	12.76	145.7	1.22
19	1.211	25.24	230.1	1.92	19	1.151	13.58	156.3	1.30
20	1.222	26.33	244.4	2.04	20	1.160	14.41	167.2	1.40
21	1.233	27.39	258.9	2.16	21	1.169	15.26	178.4	1.49
22	1.244	28.43	273.6	2.28	22	1.179	16.12	190.1	1.59
23	1.255	29.45	288.7	2 41	23	1.188	16.98	201.7	1.68
24	1.266	30.45	303.8	2.54	24	1.198	17.87	214.1	1.79
25	1.277	31.43	319.3	2.66	25	1.208	18.77	226.7	1.89
26	1.288	32.40	334.8	2.79	26	1.218	19.70	239.9	2.00
27	1.299	33.34	350.7	2.93	27	1.229	20.64	253.7	2.12
28	1.309	34.26	366.6	3.06	28	1.239	21.59	267.5	2.23
29	1.320	35.16	382.8	3.19	29	1.250	22.56	282.0	2.35
30	1.331	36.05	399.3	3.33	30	1.261	23.55	297.0	2.48
31	1.341	36.91	415.7	3.47	31	1.272	24.55	312.3	2.61
32	1.352	37.75	432.6	3.61	32	1.283	25.59	328.3	2.74
33	1.362	38.57	449.5	3.75	33	1.295	26.63	344.9	2.88
34	1.373	39.38	466.8	3.90	34	1.306	27.71	361.9	3.02
35	1.383	40.16	484.1	4.04	35	1.318	28.81	379.7	3.17
36	1.393	40.93	501.6	4.19	36	1.330	29.94	398.2	3.32
37	1.403	41.68	519.3	4.33	37	1.343	31.11	417.8	3.49
38	1.414	42.42	537.1	4.48	38	1.355	32.30	437.7	3.65
39	1.423	43.13	555.1	4.63	39	1.368	33.53	458.7	3.83
40	1.433	43.84	573.4	4.79	40	1.381	34.80	480.6	4.01
41	1.443	44.53	591.7	4.94	41	1.394	36.09	503.1	4.20
42	1.453	45.20	610.2	5.09	42	1.408	37.44	527.2	4.40
43	1.462	45.85	628.8	5.25	43	1.422	38.81	551.9	4.61
44	1.472	46.49	647.7	5.41	44	1.436	40.22	577.6	4.82
45	1.482	47.13	666.7	5.56	45	1.450	41.70	604.7	5.05
46	1.491	47.76	685.9	5.72	46	1.465	43.23	633.3	5.29
47	1.501	48.38	705.3	5.89	47	1.480	44.79	662.9	5.53
48	1.510	48.99	724.9	6.05	48	1.495	46.39	693.5	5.79
49	1.520	49.58	744.6	6.21	49	1.510	48.02	725.1	6.05
50	1.529	50.17	764.5	6.38	50	1.526	49.71	758.6	6.33
					51	1.543	51.46	794.0	6.63

The Baumé scale is that for liquids having density greater than that of water.



Set Slips on Heaviest Strings Without Brake Friction or Wear

The Dynamatic Drawworks Brake can be used while setting slips on the heaviest strings of pipe or casing without use of the friction brake. It is completely magnetic; involves no brake blocks or bands. Nothing to wear out.

- **Simple as a light circuit.**
- **Precision finger-tip control from driller's position.**
- **High torque at low speeds.**
- **Operates on ordinary light plant current.**
- **Proven in all major fields, including off-shore drilling.**
- **Readily applied to all rigs—large or small. Can be installed in the field.**

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Ajusto-Spedes • Shovel Clutches • Press Drives • Lift Truck Clutches • Electronic Controls

RELATIVE HUMIDITY AND PRESSURE OF SATURATED WATER VAPOR

Wet bulb reading deg F	Pressure of saturated vapor		(t—t'), difference between wet and dry bulb temperatures, deg. F.																		
	in. of Hg	lb. per sq. in	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0.03773	0.01853	68	38	12																	
1	.03975	.01963	69	41	15																	
2	.04186	.02056	70	43	19																	
3	.04409	.02166	71	46	22	1																
4	.04675	.02282	73	48	25	5																
5	0.04886	0.02400	74	50	28	9																
6	.05144	.02527	75	52	31	12																
7	.05412	.02658	76	54	34	16																
8	.05692	.02796	77	56	37	19	3															
9	.05988	.02941	78	58	39	22	7															
10	0.06295	0.03092	79	59	41	25	10															
11	.06618	.03251	79	61	44	28	14															
12	.06958	.03418	80	62	46	31	17	4														
13	.07309	.03590	81	64	48	33	20	8														
14	.07677	.03771	82	65	49	35	23	11														
15	0.08067	0.03963	82	66	51	38	25	14	4													
16	.08469	.04160	83	67	53	40	28	17	7													
17	.08895	.04369	84	68	55	42	30	20	10	1												
18	.09337	.04586	84	70	56	44	33	22	13	4												
19	.09797	.04812	85	71	58	46	35	25	16	7												
20	0.1028	0.05050	85	72	59	47	37	27	18	10	3											
21	.1078	.05295	86	72	60	49	39	29	21	13	6											
22	.1132	.05560	86	73	62	51	41	32	23	16	8	2										
23	.1186	.05826	87	74	63	52	43	34	26	18	11	5										
24	.1244	.06111	87	75	64	54	44	36	28	20	14	8	2									
25	0.1304	0.06405	87	76	65	55	46	37	30	23	16	10	5									
26	.1366	.06710	88	76	66	56	47	39	32	25	19	13	7	2								
27	.1432	.07034	88	77	67	58	49	41	34	27	21	15	10	5	1							
28	.1500	.07368	88	78	68	59	51	43	36	29	23	17	12	7	3							
29	.1571	.07717	89	78	69	60	52	45	38	31	25	20	15	10	5	1						
30	0.1645	0.08080	89	79	70	62	54	46	40	33	27	22	17	12	8	4						
31	.1722	.08458	89	80	71	63	55	48	42	35	29	24	19	14	10	6	2					
32	.1803	.08856	90	81	72	64	57	50	43	37	31	26	21	16	12	8	5	1				
33	.1879	.09230	90	81	73	65	58	51	45	39	33	28	23	18	14	10	7	3	0			
34	.1957	.09610	90	82	74	66	59	52	76	40	35	30	25	20	16	12	9	5	2			
35	0.2036	0.1000	91	83	75	67	60	54	47	42	36	31	26	22	18	14	10	7	4	1		
36	.2120	.1041	91	83	75	68	61	55	48	43	38	32	28	23	19	16	12	9	6	3	0	
37	.2205	.1083	91	83	75	69	62	55	49	44	39	34	29	25	21	17	14	10	8	5	2	
38	.2293	.1126	92	83	76	69	63	56	51	45	40	35	31	27	23	19	16	12	9	7	4	1
39	.2384	.1171	92	84	77	70	63	57	52	47	41	36	32	28	24	20	17	14	11	8	6	3
40	0.2478	0.1217	92	84	77	70	64	58	53	48	43	38	34	30	26	22	19	16	13	11	8	6
41	.2576	.1265	92	85	78	71	65	59	54	48	44	39	35	31	27	23	20	17	14	12	9	7
42	.2677	.1315	92	85	78	72	66	60	54	49	45	40	36	32	28	25	22	18	16	13	10	8
43	.2783	.1367	93	85	79	72	66	61	55	50	46	41	37	33	30	26	23	20	17	14	12	10
44	.2891	.1420	93	86	79	73	67	61	56	51	47	42	38	34	31	27	24	21	18	16	13	11
45	0.3003	0.1475	93	86	79	73	68	62	57	52	48	43	39	35	32	29	26	22	20	17	15	12
46	.3119	.1532	93	86	80	74	68	63	58	53	49	44	40	37	33	30	27	24	21	18	16	14
47	.3239	.1591	93	86	80	75	69	63	59	54	50	45	41	38	34	31	28	25	22	20	17	15
48	.3364	.1652	93	87	81	75	69	64	59	55	50	46	42	39	35	32	29	26	24	21	19	16
49	.3492	.1715	93	87	81	75	70	65	60	55	51	47	43	40	36	33	30	27	25	22	20	18
50	0.3624	0.1780	94	87	81	76	70	65	61	56	52	48	44	41	37	34	31	29	26	23	21	19
51	.3763	.1848	94	87	82	76	71	66	61	57	53	49	45	42	38	35	32	30	27	24	22	20
52	.3905	.1918	94	88	82	76	71	66	62	58	54	50	46	43	39	36	33	31	28	25	23	21
53	.4050	.1989	94	88	82	77	72	67	63	58	54	50	47	44	40	37	34	32	29	27	24	22
54	.4200	.2063	94	88	83	77	72	68	63	59	55	51	48	44	41	38	35	33	30	28	25	23
55	0.4357	0.2140	94	88	83	78	73	68	64	60	56	52	48	45	42	39	36	33	31	29	26	24
56	.4518	.2219	94	88	83	78	73	69	64	60	56	53	49	46	43	40	37	34	32	29	27	25
57	.4683	.2300	94	89	83	78	74	69	65	61	57	53	50	47	44	41	38	35	33	30	28	26
58	.4854	.2384	94	89	84	79	74	70	66	61	58	54	51	48	45	42	39	36	34	31	29	27
59	.5031	.2471	94	89	84	79	74	70	66	62	58	55	51	48	45	42	39	37	34	32	30	28

This Table is based on a barometric pressure of 30 in. Hg. Values are computed by formula:*

$$\text{Relative humidity, percent} = \frac{p' - [(B - p') \times 1.016(t - t')/(2800 - 1.3t')]}{p} \times 100$$

t = dry-bulb temperature
t' = wet-bulb temperature
p = vapor pressure corresponding to t
p' = vapor pressure corresponding to t'
B = barometric pressure
1.016 = factor to correct for mean radiation loss of sling psychrometer

NOTE: If stationary-type psychrometer is used, wet bulb should be exposed to air current having a velocity of not less than 14 ft. per sec.

*Formula developed by W. H. Carrier, *Trans. A.S.M.E.*, vol. 33, p. 1005.

†This table may be filed under P 207, if preferred.

LAUGH with BARNEY

An executive in New York had occasion to write to a Chinese friend in San Francisco. Mindful of the Oriental's appreciation of flowery language, and of his own duty to the cause of good public relations, he ended his letter with the wish: "May Heaven preserve you always."

To the delight of the executive's office staff, the Chinese responded with: "May Heaven pickle you, too."

* * *

Charlie: Yeah, my wife's a big pain, too. Like last night I'm takin' a bath, she has to scrub my back for me.

Amsterdam: Well, a lotta women scrub their husband's backs.

Charlie: With Brillo?

* * *

The denizens of a London pub were recently disturbed by the entrance of a man accompanied by an enormous dog. The animal flew at the oldest inhabitant who was enjoying his quiet pint and took a large lump out of the seat of his pants. It then leapt on the bar, polished off a plate of cold sausages and several pork pies, terrifying the barmaid; dashed out to the kitchen, where it seized a week's meat rations for the entire establishment; returned to the bar with them and disappeared, growling fiercely under a table in a dark corner.

The owner of the dog was roundly abused from all sides and confessed that he did find the animal a little difficult to control.

"Then get him out of my house!" roared the bar keeper.

Despite every effort by the creature's owner it stayed under the table, emitting the most frightening noises. Then the landlord had a bright idea. Turning to one of the "regulars" he said, "Go and get that damn great bull-mastiff of yours, George. He'll shift the brute."

So the said bull-mastiff was duly led in. It took a sniff and one look under the table and fled, squealing, with its tail between its legs.

"A public menace, that's what it is," yelled the barmaid. "And what's more, I've never seen such an awful looking creature."

"Yes, he is a bit queer-looking, isn't he?" answered the animal's owner. "My brother who's serving overseas sent him home to me. You ought to have seen him before I cut his mane off!"

* * *

An old-timer: One who remembers when a baby-sitter was called mother.

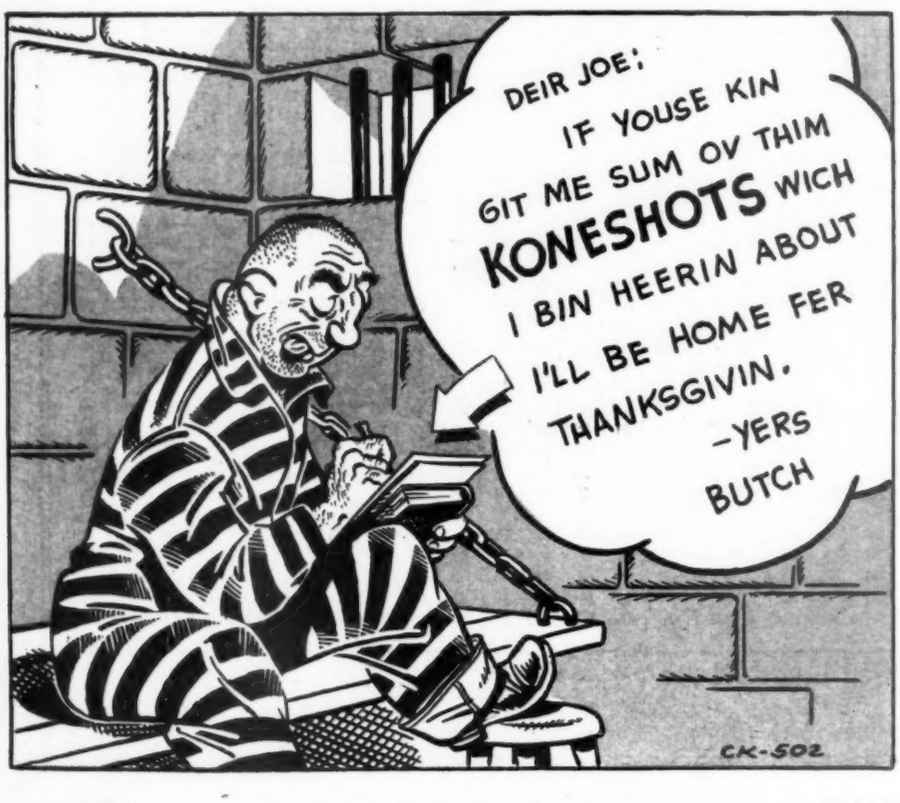
* * *

"Paw, what is a bicuspid?"

"A bicuspid, my boy, is a double-barreled spittoon."

* * *

All of us are more or less foolish, only some of us insist on proving it.



A Londoner who was used to sharing taxis made the journey North of the Border for the Edinburgh Festival. Finding the city rather crowded, he had no qualms at all in bounding into a taxi at the station, having heard the first fare announce the same hotel as his.

In he popped with a cheery smile, dropped his bags on the floor and, turning to the other passenger, said happily, "My name is Ponsonby."

"Mine," said the Scotsman, "is not."

* * *

"Johnny, who gives you the clothes you wore this morning?"

"President Truman," replied Johnny.

The teacher tried again.

"Bobby, who gives you your food?"

"Secretary Brannan," said Bobby.

The teacher was confounded, but she persisted.

"Tommy, who gives you the sun, earth, and stars?"

"God," said Tommy.

The teacher smiled with satisfaction.

A little boy yanked at Tommy's sleeve and hissed:

"Sit down, you dirty little Republican."

* * *

"Mose, do you drink coffee?"

"Yassah; 'bout fo'ty cups a day."

"My goodness! Doesn't it keep you awake?"

"Well suh, it do he'p some."

* * *

PROGRESS NOTE—The old trails where two cars could barely pass without colliding are being replaced by splendid, wide super highways where six or eight cars can collide at one time.

* * *

A spinster was shocked at the language used by workmen repairing a telephone line near her home, so she wrote the company. The foreman was requested immediately to make a report. The report read as follows:

"Me and Spike were on this job. I was up on the pole and let the hot lead fall on Spike—right down his neck. Spike looked up at me and said: "Really, Harry, you MUST be more careful'."

* * *

Hekimar was new in the store business. "Have you an account here, ma'am?" he asked.

"No," the lady replied, "but I would like to see the manager."

Hekimar led her into the manager's office and announced, "A no-account lady to see you, sir."

* * *

There was a time when a fool and his money were soon parted. Now it happens to everybody.—Minneapolis Tribune.

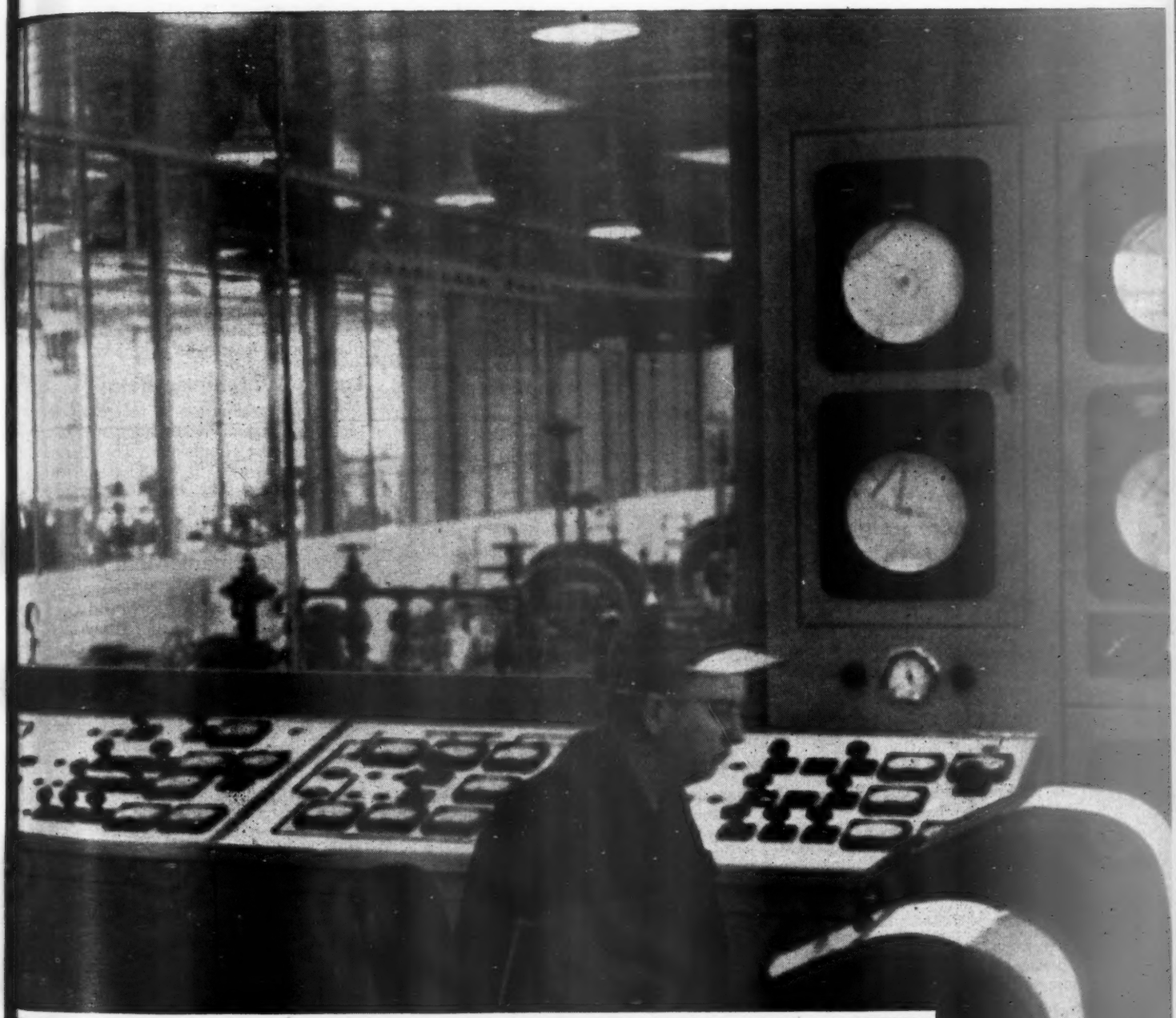
* * *

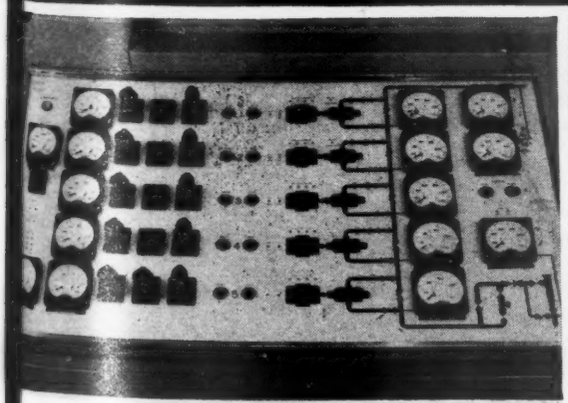
The world is full of willing people; some willing to work, the rest willing to let them.

* * *

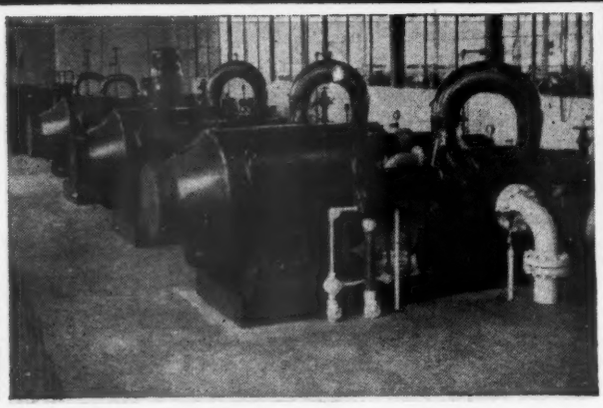
"My wife and I used to have fun at the beach. First, she would bury me in the sand, then I would bury her. One of these days I'm going down and dig her up."

They did what you can do to produce more





Plantation's highly mechanized pumping stations are operated from these Westinghouse control panels. Electrical pressure gauges were specially developed to permit the use of the simplified flow-control board.



Big explosion-resistant Westinghouse motors drive the pumps on the Plantation Pipeline. These motors were especially designed and built for pipeline duty and they have given outstanding service.

OIL and GAS TRADE NEWS

Odessa Warehouse Open

Goodall Rubber Company of Texas has opened a warehouse in Odessa to serve supply stores in the West Texas area, H. Barnard, Goodall president, has announced. A. O. (Pappy) Wells has been named West Texas representative and will make his headquarters at the Basin Warehouse. Wells, formerly with Patterson-Ballagh, will contact both supply stores and drilling contractors. John Garratt, who formerly represented Goodall in the West Texas area, will continue to be in charge of the territory, but will make his headquarters in Houston.

A. O. Wells

Tube Turns, Inc., Acquires Kerotest Manufacturing

Arrangements are completed for the acquisition of all the common stock of Kerotest Manufacturing Company, by Tube Turns, Inc. The new management will take over the operation of the plant immediately. Kerotest Manufacturing Company will continue to be operated under its own name and present officers and personnel have been retained.

New officers will be George O. Boomer, chairman of the board; John G. Seiler, vice president; Robert J. Landolt, vice president, all of Tube Turns, Inc. Walter G. Swaney, incumbent vice president and secretary, and J. D. Isaacks, vice president of Kerotest remain in the same capacity.

Goodyear Manual Out

Goodyear Tire and Rubber Company has just completed distribution of approximately 41,000 copies of the revised 1952 edition of its Tire, Battery, and Accessory Manual. This manual contains complete specifications and parts numbers in the Goodyear line for installation in automobiles up to 10 years in age. It is expected that Goodyear will distribute another revised edition of its TBA manual early next year, when data on all 1953 model automobiles become available.

Haskell Office Open

Schlumberger Well Surveying Corporation has established a location at Haskell, Texas. D. E. Corley has been appointed district manager. Corley moves to Haskell from Spur, Texas, where he was promoted to district manager recently. Completing the engineering staff at the new station are J. R. Thompson as junior engineer and B. A. Clifton, trainee engineer.

Stocking Outlets Named

Four steel warehouses in the A. M. Castle and Company chain have been signed as stocking outlets for A. O. Smith safety grating.

The Castle warehouses at San Francisco, Seattle, and Los Angeles are functioning as sub-distributors for Bufnel Company, Ltd., A. O. Smith safety grating distributor on the West Coast.

The fourth A. M. Castle outlet is a stocking distributorship of Kansas City. This branch will operate through A. O. Smith's southwest district office at Houston.

In Denver, Eaton Metal Products Company has signed as a stocking distributor for A. O. Smith safety grating.

Baroid Plant Announced

Construction has begun on a new Baroid Sales Division processing plant and warehouse in Corpus Christi, Texas, it was announced by executives of National Lead Company. The new plant, which is expected to begin operation on January 1, 1953, will produce Baroid. Its initial capacity will be 5000 tons of Baroid a month.

Allis-Chalmers Acquires LaPlant-Choate Company

All property of the LaPlant-Choate Manufacturing Company, Cedar Rapids, Iowa, was officially acquired recently by Allis-Chalmers Manufacturing Company. A. D. Dennis, president of LaPlante-Choate is general manager according to W. A. Roberts, Allis-Chalmers president. Wallace Gates is works manager and H. W. Rockwell is chief engineer. Both of these men held the same positions in the LaPlant-Choate organization.

Canada Office Open

The National Supply Company, Ltd., has opened a sales office at 205 McAra Block, 1855 Scarth Street, Regina, Saskatchewan, Canada. James H. Linstead is sales representative.

Le Roi Stock Purchased

E. O. Boshell, president and chairman of the board of Westinghouse Air Brake Company, Wilmerding, Pennsylvania; W. C. Buchanan, chairman of the board of Le Roi Company, Milwaukee, Wisconsin; and T. O. Liebscher, president of Le Roi, have announced that Westinghouse Air Brake Company has purchased a majority interest in Le Roi Company.

Boshell advises, "The acquisition of Le Roi Company adds appreciably to the enlargement of the compressor products of Westinghouse Air Brake Company. It is our intention to retain the name, organization, officers, employees, plant locations, of the company."

Larkin Warehouse Setup

A new warehouse was recently completed by Larkin Packer Company, Inc., in Shreveport, Louisiana. The Larkin warehouse is a 40 ft by 80 ft quonset type building. The building includes warehouse and office space as well as living quarters for the representative.

Water Treatment Meet Held

A water treatment engineer's meeting, sponsored by Dearborn Chemical Company, was held in Chicago, Illinois, recently. Among the speakers participating in the meeting were R. A. Carr, present, Dearborn Chemical Company; M. F. Obrecht, professor, of chemical engineering, Michigan State College; and E. P. Fager, vice president, Dearborn Chemical Company.

New Division Set Up

National Lead Company has announced formation of the Pioneer Alloy Products Division, which has taken over the manufacturing operations of the Pioneer Alloy Products Company, Inc., of Cleveland, Ohio. Manufacturing operations of the new division will be in Ellwood City, Pennsylvania. L. J. Gambow, general manager of the Pioneer Alloy Products Company, Inc., will become sales manager of this new division.

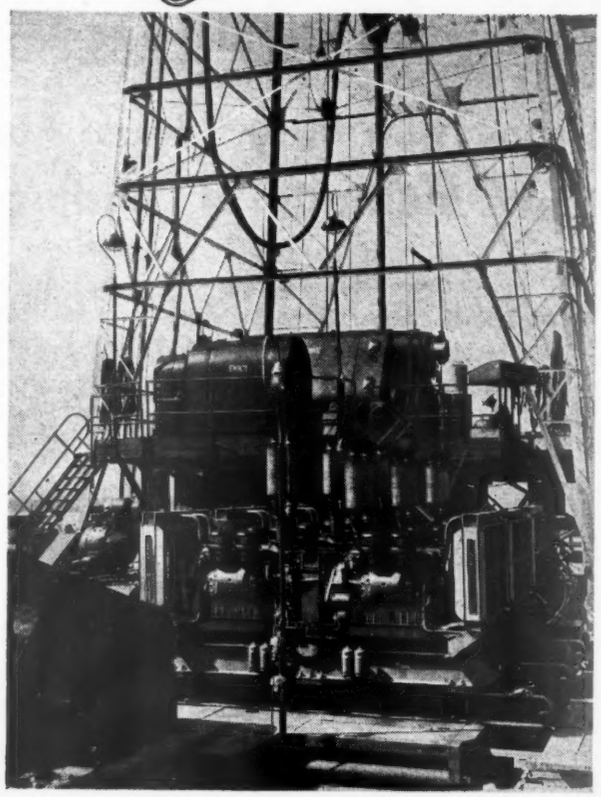
National Supply Company Plant. This new oil field supply store at Harvey, Louisiana, is 50 by 100 ft compared to the old store, 30 by 60 ft. K. H. McFann is manager and L. A. J. Monroe is district manager. Building includes warehouse, storage yard, and dormitory.

GM DIESEL
CASE HISTORY No. 47-903

USER: Coastal Drilling Co., Bakersfield, Calif., operating in San Joaquin Valley.

INSTALLATION: Three GM Diesel Quads, powering an Emsco J-1250 rig and two 8" x 20" Gardner-Denver mud pumps. Engines were purchased August 1, 1947.

PERFORMANCE: Three Quads have each operated 38,000 hours and never been off the rig for repairs. One of them operated 23,000 hours before pistons and liners were changed right on the rig.



This Diesel has worked 38,000 hours

without being off the rig for repairs

For five full years these three General Motors Diesel Quads have been drilling wells without needing to be removed from the rig. Costly down time is reduced to a minimum with GM Diesel multiple engine units because one engine can be serviced while others keep working. With good maintenance and parts replacement when needed, GM Diesels give thousands of hours of dependable service. They're compact—fit within road width—are easier to move. Two-cycle operation makes them fast accelerating for quicker round trips. Investigate GM Diesels before specifying power for your next rig.

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN
SINGLE ENGINES...32 to 275 H.P. MULTIPLE UNITS...Up to 840 H.P. @

It pays to Standardize on

GM
GENERAL MOTORS
DIESEL POWER

Write for booklet, "A 30,000,000 Horsepower Insurance Policy" that tells you why.

•SwRI

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Have You Any Ideas About New Methods of Finding Oil?

If you have a really good prospecting idea, write to Southwest Research Institute, a non-profit scientific research laboratory. Your idea or invention will be carefully and impartially evaluated and you will be furnished with a scientific report that may help you develop a profitable market.

This research service is performed for inventors without charge — and your inquiries will be kept in strict confidence upon request.

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Southwest Research Institute
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Everyone walks safely, confidently on Blaw-Knox Electroforged Steel Grating . . . the one-piece panels stay rigid and strong—without shimmy or shake—because there are no parts to work loose. Twisted cross bars provide sure footing under the most adverse conditions. For complete information, write for Bulletin 2365.

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BLAW-KNOX DIVISION of Blaw-Knox Co.
2126 Farmers Bank Bldg.,
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BLAW-KNOX ELECTROFORGED STEEL GRATING

Trade News

Ajax Celebrates Diamond Jubilee

Now in its 75th year, Ajax Iron Works commemorated the anniversary recently, with a reception for prominent figures in the industry and an inspection trip through the plants at Corry, Pennsylvania, where Ajax gas engines are manufactured. In making the announcement, John H. Castor, vice president and general manager of the company, remarked that although three-quarters of a century of unbroken business activity is not unusual in American business generally, such a span in oil covers almost the lifetime of the industry.

J. H. Castor

Cleco Appoints Agents

The Cleco Division of the Reed Roller Bit Company, Houston, Texas, has announced the appointment of Anna M. Fusco, DBA, S. L. Fusco, Los Angeles, California; Pauli and Griffin Company, San Francisco, California; William J. Boss Company, Glens Falls, New York; and Bison Machinery and Tool Company, Buffalo, New York, as distributors for Cleco products in their areas.

Montana Branch Open

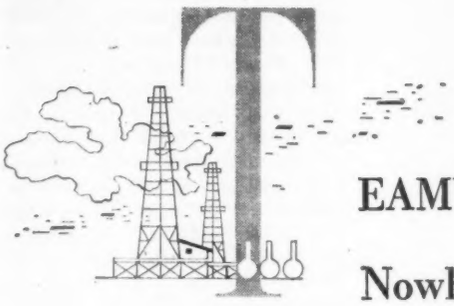
Opening of a new branch sales and service office, including a stock of parts, at Glendive, Montana, by the Maloney-Crawford Tank & Manufacturing Company of Tulsa, is announced by S. P. Wallace, president. Frank B. Matthews, formerly with Maloney-Crawford at Edmonton, will be in charge, under the area supervision of G. M. Cheatham, vice president of Maloney-Crawford of Canada, Ltd., of Edmonton.

B&W Tubular Products Opens New Office

In order to provide better service for the increasing numbers of users of tubular products in central and up-state New York, the tubular products division of The Babcock and Wilcox Company has established a district sales office in Syracuse, it was announced by W. J. Thomas, general sales manager of the division. Thomas also announced that J. Y. McCandless had been appointed in charge of the new office. The office will be at 205 Harrison Street, Syracuse 2, New York.

McGregor Assets Obtained

All assets of the McGregor Working Barrel Company has been acquired by Merle Phipps of Clintonville, R. A. Hindman and P. T. Clark of Butler, Pennsylvania. The company will continue to operate under the name of McGregor Working Barrel Company. The present employees, including C. E. Brown will continue in their respective capacities with the new company.



TEAMWORK gets the job done!

Nowhere is teamwork more essential to accomplishment than in the Oil Industry. Getting the job done with maximum speed and efficiency depends upon teamwork between men and the tools of their trade — and successful application of those tools by their ultimate users depends upon teamwork between the manufacturers and distributors.

That's where REPUBLIC SUPPLY enters the oil drilling and production picture. Serving the Industry from more than 50 convenient locations throughout the oil country, REPUBLIC SUPPLY STORES maintain complete stocks of time-tested and field-proven products designed to meet tomorrow's needs today.

Republic Supply

COMPANY

GENERAL OFFICES - - - HOUSTON 1, TEXAS

We salute a great teamwork leader in a great industry—
THE AMERICAN PETROLEUM INSTITUTE
—on the occasion of its
32nd ANNUAL MEETING

K. W. Lineberry H. A. Ruysser, Jr. C. H. Myers R. W. Nichols F. C. Myers

At top is Black, Sivalls, and Bryson's Oklahoma City plant.

Celebrates 60th Year

Black, Sivalls and Bryson, Inc., recently completed its sixtieth year of continuous operation. Beginning in Ohio as a small company building wood tanks for oil storage, BS&B is now a company of 6 manufacturing plants and 52 branches and sales offices, employing over 2500 people and doing an international business. A $2,000,000 expansion of plant facilities has been virtually completed by BS&B. The program includes major expansion of the Oklahoma City and Kansas City plants, and expansion and relocation of the Odessa facilities.

Kenneth W. Lineberry is president of BS&B; Henry A. Ruysser, Jr., vice president and general manager of sales; Charles H. Myers, vice president in charge of the Oklahoma City plant; Ralph W. Nichols, manager of oil and gas equipment sales; Floyd C. Myers, manager of branch operations; Jimmy Dvoracek, sales manager for Climax Controls; Lu N. Tidd, contract sales manager. Regional sales managers are Ralph Stevens, Hal Fessler, Lee Kelton, Ed Nelson, and Ross Baze.

Frank's Films in the Making

Three technicolor sound films are being produced for Franks Manufacturing Corporation, Tulsa, Oklahoma, to demonstrate their new 1953 models of portable well servicing and workover units, according to Carl White, Jr., Franks president. The first film to be completed, "The Cruiser Story," includes shots of many West Texas well servicing contractors participating in a barbecue that was held for them at Odessa, Texas. Pictures of the Franks plant in Tulsa are also included in the films. Similar films on Franks "Rocket" and "Comet" lines are still in production.

AMEPCO Produces Pipe

The American Extruded Products Company has expanded its facilities to include the production of plastic pipe for water, gas, oil, and chemical lines. Not effected by electrolytic corrosion and chemical resistant, Amepco plastic pipe is made of 100 per cent virgin plastic and is available in a full range of sizes from ½ to 6-in. diameter and up.

New Canadian Company Formed by Eclipse Fuel

A new company, Eclipse Fuel Engineering Company, of Canada, Ltd., has been formed to handle sales and service on "Eclipse" products in Canada, according to executives of the parent company, Eclipse Fuel Engineering Company of Rockford, Illinois. Numerous standard combustion and gas distribution products and components will be locally stocked to speed shipment, and the entire line will be represented. New offices for the company have been established at 705 Bloor Street, West, in Toronto. The office will be managed by Gordon E. Bouvier.

G. E. Bouvier

Samson Sales Agents Named

Elgin Softener Corporation has announced the appointment of Samson Sales Company as its representative for central and northern California and Nevada, with headquarters at 420 Market Street, San Francisco. Samson Sales will handle the complete line of Elgin zeolite water softeners, filters, deionizers, boiler, etc.

WECO to Handle Sales for Chiksan in Williston Basin

The Well Equipment Manufacturing Corporation division of Chiksan Company has taken over the distribution and sale of Chiksan and Weco products in the Rocky Mountain and Williston Basin areas. The states affected include Montana, Idaho, Wyoming, Colorado, North and South Dakota, that portion of Nebraska bounded on the east. Offices are being established by Well Equipment in Casper, Wyoming, and in Denver, Colorado. W. C. Hull, who has been covering the Kansas area for Weco, will make his headquarters in Casper. L. L. Durkin, who formerly covered the West Texas-New Mexico territory, has been transferred to Denver.

Bethlehem Opens New Store At Tioga, North Dakota

Bethlehem Supply Company announces the opening of its newest modern store at Tioga, North Dakota. This new installation is the first major supply company store to locate in the heart of the activity in the Tioga-Beaver Lodge area of the Williston Basin. The new store will be under the supervision of E. S. Lewis, district manager at Casper, Wyoming. D. B. Afflack, formerly store manager at Great Bend, Kansas, will be the store manager. The store will be staffed with trained personnel.

Engineering Awards Granted

The results of the fifth Annual Engineering Undergraduate Award and Scholarship Design Program have been announced by The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio. Engineering undergraduates in 23 different schools have been given national engineering recognition and awards totaling $5,000. Scholarship funds of $1750 have also been awarded to three schools in honor of the first three award winners. Awards were made for the best designs of machinery and structures stressing the value of arc welded construction.

Franklin Supply Moves

Franklin Supply Company has moved its Dallas, Texas, office to 1428-30 Irwin Keasler Building. L. H. Strouse, vice president, will make his headquarters in Dallas and will reside at 6440 Brookshire Drive.

English Pumps Will Be Distributed in U.S.

The National Supply Company has announced that it is now sole distributor within the U.S. for Lister diesel engines, manufactured by R. A. Lister and Company, Ltd., Dursley, Gloucestershire, England. Arrangements to this effect were made following a recent visit to the United States by Sir Percy Lister, chairman of R. A. Lister & Company, Ltd., and a subsequent visit to England by F. Howard Kilberry, general manager of National Supply's engine division, Springfield, Ohio.

Norris Opens New Branch

W. C. Norris, Manufacturer, Inc., have expanded their facilities and opened a new branch office and warehouse at Houston, Texas, according to Ed C. Bolger, president. The new building is 70 by 200 ft and provides 14,000 sq ft of warehouse space. Complete stocks of Norris products will be carried at the Houston branch. C. L. "Les" Snelling, former city salesman for Norris, is the manager of the new Houston branch. He joined the purchasing department at Norris 10 years ago.

C. L. Snelling

W. C. Norris, Manufacturer's new warehouse and branch office in Houston.

IDECO Equipment to Be Made By English Manufacturers

Dr. Hans Berger, of Zurich, Switzerland, director of Dresser Atkiengesellschaft, announced his company had concluded arrangements with Woodfield Hoist and Associated Industries, Limited, of Rochester, England, for the manufacture in England by Woodfield of the complete line of IDECO oil field machinery and equipment. Dresser Atkiengesellschaft is an European subsidiary of Dresser Industries, Inc., of Dallas.

National Supply Men Attend Training School

Twenty-two young college graduates spent a month in Pittsburgh, Pennsylvania, recently attending executive seminar as part of a unique training program offered by The National Supply Company. Each of the young men has had several months experience at one of the company's 114 oil country supply stores. In the seminar they have learned about the company's accounting and auditing practices, its industrial relations, its purchasing and traffic departments, its export division, and the construction of its stores. A. E. Walker, president and chairman of the board, and A. W. McKinney, executive vice president, are among 40 top flight men who composed the faculty.

Fuel System Conditioner Announced by Gulf Oil

An "all-year automobile fuel system conditioner" developed by Gulf Oil Corportation to answer a wide-spread demand for such a product among motorists, has just been placed on the market. Named Gulf SDL (for solvent, drier, lubricant), it consists of a complex blend of ingredients selected to alleviate the common troubles encountered in fuel systems. It contains solvents to remove harmful gum which may be present in carburetor and fuel system. It also protects against further gum formation (which may occur under some operating and storage conditions), thus helping cleanse and keep important parts free-operating, it was reported.

B & W Plans New Boiler Plant

The Babcock and Wilcox Company has purchased facilities of a former shipyard from the Brunswick Port Authority at Brunswick, Georgia, and will convert it into a plant to build boilers and related equipment. The property involved consists of about 110 acres with about 250,000 sq ft under roof and was formerly the J. A. Jones shipyard before being acquired by the Brunswick Port Authority in 1945. Rehabilitation work on the plant, together with installing the necessary new equipment, will begin immediately, it was announced, and production will begin about the first of the year.

Stratoflex Announces New Office, Personnel Changes

Ken W. Davis, president of Stratoflex, Inc., has announced the opening of a new sales office in Los Angeles, California, at 1129-30 Petroleum Building, 714 West Olympic Boulevard, as well as several important personnel transfers and promotions in the organization.

Promotions announced by President Davis include that of J. D. Willis, former manager of the customer's order section and purchasing agent at Fort Worth, to office and warehouse manager at the same location. K. G. Hibben, Fort Worth purchasing department, has been promoted to sales representative at Birmingham, Alabama, replacing H. W. Priest, sales engineer, who has been transferred to the company's Wichita, Kansas, office. B. L. Matheson, has been promoted to sales representative at Houston, Texas, replacing A. B. Quinn, sales engineer who has been transferred to the new Los Angeles, California, office.

New Sales Office Opened

Opening of a new sales and engineering office in Dallas, Texas, was announced by President Thomas J. Bannan of Western Gear Works. Paul Marmont, formerly with the company's Portland office, will be in charge. The Dallas office represents the products and services of the entire group of five Pacific-Western companies.

Oil Brokerage Firm Set Up

William H. Huett and J. W. Marshall have set up the Marshall-Huett and Company oil brokerage firm. Headquarters for the new firm are 1633 Buckner Boulevard, Dallas, Texas. The company will buy and sell oil and gas leases, royalties, and production and will handle pipe, casing, and oil field supplies. The company grew out of side line activities by both men. Huett had his own company, the Huett Ferry and Brokerage Company, and Marshall was an automobile and aircraft dealer in Dallas.

SAVE THIS WAY
SAND-BANUM
REMOVES AND PREVENTS BOILER SCALE AND CORROSION
Clean Boilers Mean Less Fuel, More Power, Fewer Shut-downs
Write for Details
SAND-BANUM SPECIAL
TABLETS REMOVE AND PREVENT RUST AND SCALE IN ALL RADIATOR COOLING SYSTEMS
Clean Cooling Systems Mean Reduced Fuel Costs
AMERICAN SAND-BANUM CO.
Established 1926
9 Rockefeller Plaza
New York 20, N.Y.

Ralph N. Brodie Company plant situated on a 6½-acre tract in the San Leandro, California, industrial area.

Big Four Machine Expands Operations

Big Four Machine and Supply Company has announced an important expansion of its operations, including the opening of a complete warehouse at 525 SE 29th Street, Oklahoma City. General offices only recently opened at Oklahoma City, have also been moved to the new warehouse location, according to John R. Riley, president. New warehouse facilities will house complete stocks of the products manufactured by Big Four as well as Beaver Tool and Machine Company of Maysville.

H. K. Porter Company Buys Watson-Stillman Company

In a move to further diversify its manufacturing operations, H. K. Porter Company, Inc., has acquired The Watson-Stillman Company, Roselle, New Jersey, manufacturers of forged steel fittings and hydraulic equipment, it was announced by T. M. Evans, president of Porter. The Watson-Stillman Company, well known throughout the industry, manufactures a complete line of forged steel fittings, hydraulic presses, jacks, pumps, shears, pipe benders and other hydraulic equipment.

Brodie Plant Complete

Ralph N. Brodie Company, Inc., recently completed an extensive new plant on a 6½-acre tract in the San Leandro, California, industrial area near Oakland International Airport. This latest expansion provides substantially enlarged engineering, research, production and office facilities and represents the third major expansion over the period of 25 years in which the firm has specialized in petroleum metering equipment.

Export Corporation Formed

Bigelow-Liptak Corporation announces the formation early this year of a new subsidiary, Bigelow-Liptak Export Corporation, which was organized to conform with the Western Hemisphere Trading Act. A Michigan corporation, its main office is at 2550 West Grand Boulevard, Detroit 8, Michigan. Officers of the company are H. Stanley Ford, president; Richard E. Sampson, vice president and manager; Ernest B. Wolf, vice president; Arthur L. Bert, secretary and treasurer, who also constitute the directors of the corporation.

Lane-Wells Buys Acreage

Lane-Wells Company has purchased five acres of land immediately adjoining its present head office, plant, and shops property at 5610 South Soto Street, Los Angeles, according to Rodney S. Durkee, president. This will more than double the size of the company's Los Angeles headquarters.

Cut Maintenance Costs— Stop Scale in Diesels

PROBLEM: Scale in Diesel cooling systems—building up to 2 inches in about 6 weeks... impairing engine efficiency... often resulting in cracked heads and blocks.

SOLUTION: Add small amount of Oakite Airefiner 52 to jacket cooling water.

RESULTS: No descaling necessary after 15 months of operation... all engines operating at proper temperature... cost of maintenance reduced 87% ... manual labor eliminated.

That's the experience of a Texas producer. It could be yours, too. Call your local Oakite Technical Service Representative. Or write Oakite Products, Inc., 48 Rector St., New York 6, N. Y.

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MATERIALS • METHODS • SERVICE

Technical Service Representatives Located in Principal Cities of United States and Canada

ROPER rotary PUMPS

DEPENDABLE SERVICE FOR A WIDE RANGE OF USES

SERIES "K"

- Quiet
- Efficient
- Economical

The *Series K* pump shown — for hydraulic service and fuel supply — is one of four standard models in the Roper line. Others include: *Series F* for use with clean liquids of all kinds; *Series H* for high pressure applications, especially hydraulic mechanisms; and *Series 3600* for general purpose work handling thin or thick liquids. Roper Pumps are noted for quiet operation, high volumetric efficiency, and ruggedness coupled with compact design. Models are standard fitted or bronze fitted; can be supplied with or without built-in relief valve. Sizes range from 3/4 to 300 G.P.M. — Pressures to 1000 P.S.I. Send for catalog to know complete details.

GEO. D. ROPER CORP.
731 Blackhawk Park Ave.
Rockford, Illinois

ROPER Rotary Pumps

Gardner-Denver Meets

The Gardner-Denver staff of oil field service specialists recently attended a week-long round table discussion on slush pump operations and trends. Meetings were planned to cover all phases of oil field installation and repair service. Classes included welding demonstrations, metal analyses, and discussions on repair parts, etc. The meetings were conducted by R. J. Bauer.

Roberts Is with Enterprise

J. C. Roberts, 22 mission B-29 pilot, returned to Enterprise Engine and Machinery Company in 1946 to take special engineering work at the University of California. Following many months of diesel development work for Enterprise, he became assistant manager of the process division.

French, Italian Workers Take Worthington Jobs

One French and one Italian worker from plants abroad are now learning the production know-how, customs and ways of the American worker at the Harrison plant of Worthington Corporation. They'll be at it for one year. The two workers are part of a group of 200 now working in plants throughout the U. S.

Roger Coulon of Paris is in training at the Worthington plant as an external grinder, a job consisting of tooling and finishing machinery parts. Bruno Avaldi, 29, was hired for his year's stay as a toolmaker. He has been a foreman at Grattarola and Compagne at Cerianai near Turin in Northern Italy.

Security Engineering's Dallas, Texas, plant has begun partial operation. Otto Hammer, Security president, announced that it will be several months before plant operation will reach top level production. The Dallas plant will be devoted exclusively to the manufacture of 3-cutter rock bits. The new plant covers 62,000 ft.

Standard Magnesium Unit Purchased

The M. J. Crose Manufacturing Company, Inc., recently purchased manufacturing facilities and plant of the Standard Magnesium Corporation in Tulsa, Oklahoma. The new plant will be known as the Standard Magnesium division of the Crose company. D. M. (Mike) Curran, secretary-treasurer, said the Crose company manufactures equipment for installation of pipe line facilities.

Hartley Davis will be manager of Standard Magnesium division. Sale and installation of anodes to the pipe line industry will be handled by the Pipeline Anode Corporation. Sales manager will be Yale Titterington. Chief engineer for Pipeline Anode will be Hugh Brady.

Pressed Steel Tank Buys Downingtown Iron Works

Herman Merker, president of Pressed Steel Tank Company, Milwaukee, Wisconsin, and Penrose M. Davis, president of Downingtown Iron Works, Inc., Downingtown, Pennsylvania, issued a joint statement announcing the merger of the interests of the two companies through the acquisition by Pressed Steel Tank of all outstanding stock of Downingtown.

H. Merker

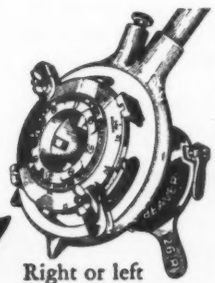
"Downingtown Iron Works," Merker said, "retains its existing corporate structure, and will be operated as a division of Pressed Steel Tank Company. No changes in management or personnel are contemplated," he added.

SIMPLICITY!

Low Upkeep Cost
Trouble-Free

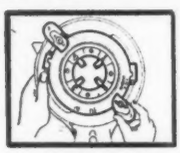
BEAVER NO. 26-R
1 TO 2-INCH PIPE THREADER

5 OUTSTANDING ADVANTAGES

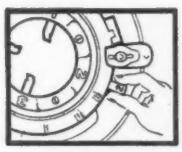


Right or left hand models

• The new Beaver 26-R is a greatly improved and simplified successor to the "old Beaver 26," popular for 40 years. Drive ring is on top—in line with dies for easy cutting. Oversize, undersize or standard threads can be cut of uniform length. Has "radio dial" setting. Change size in 2 seconds without tools. Standard taper or electric conduit threads. One set dies. No bushings.

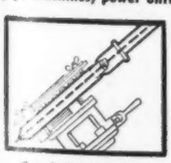


Radio Dial Setting Change in 2 Seconds



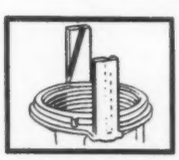
Dies Easily Removed from Outside

BEAVER PIPE TOOLS, INC.
256-300 DANA AVENUE • WARREN, OHIO, U. S. A.
"Over 50 Years of Friendly Service"
Write for complete general catalog—covering full line of pipe machines, power units and hand tools, 1/8 to 12 inches.



Straight Line Pull Easier Cutting

Universal Chuck · Accurate Centering · No Bushings



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WHERE AND WHEN YOU WANT IT

* caustic soda (FLAKE, SOLID, LIQUID)	* chlorine
* muriatic acid	* oil well and industrial salt

ANYWHERE IN THE ROCKY MOUNTAIN, MID-CONTINENT AND SOUTHWEST AREAS

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GEARED TO SERVE THE OIL INDUSTRY

Wichita, Kansas • Denver City, Texas • Midland, Texas • Denver, Colorado

TRADE PERSONALS

E. E. (Gene) Buckner has been named as sales agent for the Southwest Texas Gulf territory of Web Wilson Oil Tools, Inc., with headquarters at Corpus Christi. Buckner has just completed a 17-year stay with Baash-Ross, prior to which he had years of experience in drilling and as a small owner-producer.

E. E. (Gene) Buckner

Fred S. Durham, Jr., vice president and secretary who for the past several years has supervised Bonney Forge and Tool Works sales efforts, will take on additional responsibilities as dircetor of sales. **Harry J. Seaman** has been appointed field supervisor; and **E. S. Sensenderfer** becomes manager of merchandising. Sensenderfer will continue to direct Bonney's advertising. He also will be responsible for sales promotion, the production of all sales materials, and will direct Bonney's participation in trade shows and exhibits. Sensenderfer will work closely with Durham in the development of all Bonney sales, advertising, and merchandising programs.

E. O. Boshell, G. V. Meyers, and **J. Carlson** have been elected directors of Le Roi Company.

Other directors are T. O. Liebscher, Le Roi's president; P. W. Eells, Le Roi's vice president, and R. R. Morgan who is vice president in charge of Le Roi's Cleveland Division. E. O. Boshell is chairman of the board of directors and president of Westinghouse Air Brake Company of Wilmerding, Pennsylvania. Meyers is a controller of the Pennsylvania firm, while Carlson is the assistant to the president.

T. A. Sullivan, supervisor of order service in the A. O. Smith Corporation process equipment division for the last year, has been named product manager for the pressure vessels in the division. At the same time it was announced that **R. T. Springate** has joined the process equipment division as superintendent of production control. Springate had been factory manager of the A. O. Smith truck frame division. Succeeding him in his truck frame post is **T. E. Dillon,** formerly manager of manufacturing for the passenger frame plants under Peter Blake.

C. P. Brown

Carl P. Brown has been named manager of industrial and export sales of Kobe, Inc., division of Dresser Equipment Company. Brown is a graduate of Cornell. He was formerly with the Erie Railroad and joined Kobe, Inc., in 1947.

L. E. Brungraber has been transferred from the engineering department to Bigelow-Liptak Corporation's, Detroit, Michigan, sales staff in New York City. He will work out of the New York office at 50 Church Street. He is a graduate of Iowa State's engineering school.

G. A. Schiller

George A. Schiller has been named assistant sales manager of the Dollinger Corporation. He was formerly associated with the Dustex Corporation, and received a BS in mechanical engineering at the University of Buffalo.

L. M. Gasche

G. A. Gillespie

Louis M. Gasche was recently elected to the office of vice president and assistant manager of Fred E. Cooper, Inc. Gasche comes into his new position with many years of sales experience and full knowledge of the company's equipment and policies, having been with the company as a sales engineer since 1938.

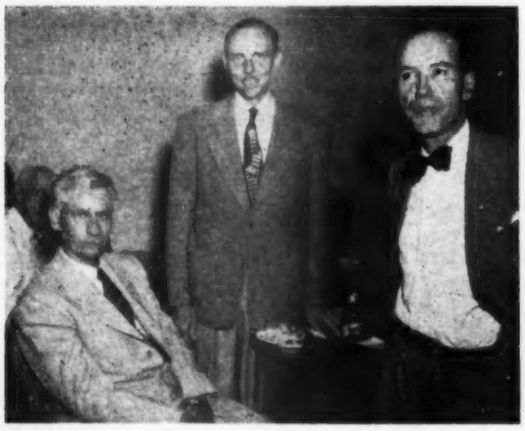
He is a graduate of Kansas State College, Manhattan.

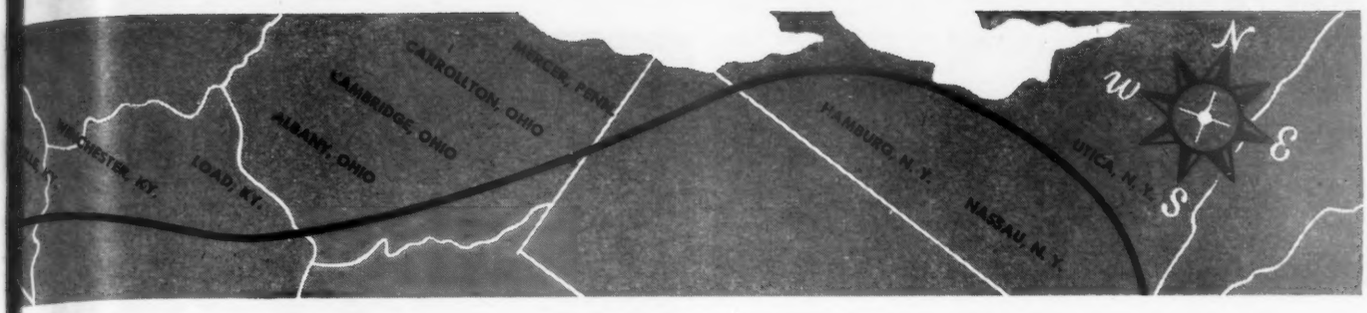
George A. Gillespie has been appointed as resident manager of the Paris, France, office for the tractor division, Allis-Chalmers Manufacturing company. Gillespie has been territory sales manager for Europe, North Africa, and the Middle East with headquarters in Milwaukee, since joining Allis-Chalmers in 1948. In his new position he will supervise sales of the company's tractor division products throughout continental Europe.

Stephen C. May has been appointed Elgin Softener Corporation sales representative for Georgia, Florida, and lower South Carolina, with headquarters at 585 Sherwood Road, Atlanta. May has had many years experience in the mechanical and hydraulic field.

Leo C. King was elected president at a recent meeting of the stockholders of The Happy Company. **Paul E. Mahaffey,** founder and president of the Happy Company since its organization January 1, 1920, was elevated to chairman of the board. King has been with the Happy organization since 1924. He moved from Seminole to the home office in Tulsa as vice president in charge of sales in 1943. He has continued in that capacity until his election to presidency of the Happy Company.

At opening of the new Sidney, Nebraska, offices of Schlumberger Well Surveying Corporation, are: Ed Stewart, division manager, Ohio Oil Company; A. O. Phares, district manager, Schlumberger, Sidney; and Paul Chabas, area manager, Schlumberger, Denver. At right are Happy Company Officers. Leo C. King, third from left, new president of the Happy Company, Tulsa, holds policy meeting with other company officers. Seated from left to right they are Roy Lindley, secretary-treasurer; John E. Mahaffey, vice president; Leo C. King, president, and Paul E. Mahaffey, chairman of the board. Mahaffey is the founder of the company and served as president before his election to the board.





2000-Mile Tennessee Gas Line —Longest in Country— operating 98 Worthington Compressors

46 Worthington UTC Engine Compressors help pump 1,250,000,000 cu ft a day

All along the Tennessee Gas Transmission Company line, from the Gulf Coast to the New England states border, you'll find Worthington UTC gas-engine compressors on the job.

At last report, more than 1,250,000,000 cu ft of gas was being sent through the line daily. A total of 46 Worthington UTC engine compressors are now installed at eight different compressor station locations.

All these UTC units use the Worthington *Uniflo timed-scavenging method*—one big reason for the smooth performance they give. Uniflo scavenging assures a "clean sweep" of burned gases.

While built primarily for pipeline gas compression, the UTC is ideal for many other jobs such as: pressure maintenance on oil wells; varied service in natural gasoline plants; on solvent extraction, vapor recovery, recycling and stabilization of gases in oil refineries; in petro-chemical processing of products made from natural gas under pressure; and in many refrigeration applications.

If your process requires gas compression and you have a suitable gas available for fuel, the Worthington Uniflo UTC can do the best possible job for you.

Sizes range from 1,000 to 2,000 hp. For further information, contact the nearest Worthington District Office or write for Bulletin S-500-B23B.

Worthington Corporation, Engine Division, Buffalo, N. Y.

EK.2.2

OUTPERFORM A WORTHINGTON

WORTHINGTON

Engine Compressors

Trade Personals

F. E. Palmer

A. B. McDaniel

J. J. Doyle

W. B. Kirkland

▸ **Floyd E. (Hero) Palmer,** assistant general sales manager of Baroid Sales Division, National Lead Company, has been transferred from the Houston, Texas, headquarters to Denver, Colorado, for closer contact with the Rocky Mountain territory. Palmer began his association with Baroid some 20 years ago.

A. B. McDaniel has been appointed assistant general sales manager for Baroid Sales Division, National Lead Company. McDaniel has been with the Baroid organization since 1935. Prior to this, he was with Standard Oil of Bolivia and Phillips Petroleum Company.

James J. Doyle has been appointed distribution manager of Baroid Sales Division, National Lead with headquarters in Houston, Texas. Doyle was graduated from Texas A. & M. College in 1939 and immediately joined the Baroid organization.

W. B. Kirkland has been appointed purchasing agent for Baroid Sales Division, with headquarters in Houston, Texas. Kirkland is a graduate of South Texas College of Commerce. He was formerly associated with the Lone Star Roofing Company.

▸ **L. L. Lewis** has been named as general solicitor, United States Steel Company. Other appointments are **A. L. Mulling, Merrill Russell,** and **R. Heath Larry** as assistant general solicitors. Lewis, who has been the company's associate general solicitor, was graduated from the University of Pittsburgh in 1934. He joined U. S. Steel that year as an attorney. Lewis became general attorney of Carnegie-Illinois Steel Corporation in 1948. Mulling, a graduate of Mercer University, was made a general attorney and assistant secretary of U. S. Steel Corporation of Delaware. Rusell was graduated from the University of Nebraska in 1926. He was associated with Scott, MacLeish and Falk, and later Knapp, Cushing, Hershberger, and Stevenson before joining U. S. Steel.

Arthur H. Beasley

▸ **Arthur H. Beasley** has been named Wagner Electric Corporation's manager of Memphis, Tennessee, sales branch. Beasley succeeds **A. Callaway Allen,** who recently became sales manager of Wagner's Electrical Division. Beasley, a graduate of Purdue University, joined the Wagner company in 1936.

▸ **Phil Montgomery** has returned to the Halliburton Oil Well Cementing Company, after a year with the Petroleum Administration for Defense in Washington, D. C. Manager of Halliburton's mechanical research and development department before his PAD service, Montgomery has been named to a new position — technical coordinator for cementing services. An engineering graduate of the University of Oklahoma, Montgomery has been with Halliburton for 20 years.

P. Montgomery

▸ **Robert E. Hensley** has been assigned to Cooper-Bessemer's Tulsa, Oklahoma, office. Working under the direction of Byron L. Potter, branch manager, Hensley will concentrate his efforts to engineering the installation of diesel engines, gas and air compressors for pipe lines, refineries, and chemical plants in the Oklahoma area. He is an engineering graduate of Oklahoma A. & M.

▸ **Floyd Hubert,** American Manufacturing Company of Texas, has been named secretary-treasurer to the post of general manager; **J. E. Lott,** plant superintendent to vice president in charge of

Hubert

Lott

Hestand

operations; and **Rue S. Hestand,** chief engineer to vice president in charge of engineering. Hubert joined the company in 1942 and for the past several years has served as secretary and treasurer. Lott came with the firm in 1934 and has served in various plant and supervisory capacities. Hestand joined American in 1942 and since that time has served as assistant chief engineer and chief engineer prior to his promotion.

▸ **Henry D. Noll** has been promoted to director of engineering, Houdry Process Corporation. **A. Wesley Hoge** was named manager of engineering; **Theodore A. Burtis,** supervisor of process engineering; **Josef W. Schall,** director of development, and **John B. Maerker,** section chief of development.

▸ **Donald B. Ross** has joined the Sawyer-Jensen Company of Tulsa, Oklahoma, as a partner, and the firm name has been changed to Sawyer-Jensen-Ross. In keeping with the company's growth over the last four years, and its program of development of new equipment specialities Ross will handle the promotion and sales.

D. B. Ross

▸ **Theodore B. Manheim** has been added to Dearborn Chemical Company's sales staff. He will take over the Philadelphia and Delaware territory, and will make his headquarters in Philadelphia. Manheim comes to Dearborn from Scholler Brothers, Inc., of Philadelphia.

▸ **W. L. Reynolds** has been appointed to the position of purchasing agent for Iverson Supply Company and **H. D. Lawver** as assistant purchasing agent. Before becoming associated with Iverson, Reynolds served as purchasing agent and director of purchases for International Derrick and Equipment Company.

W. L. Reynolds

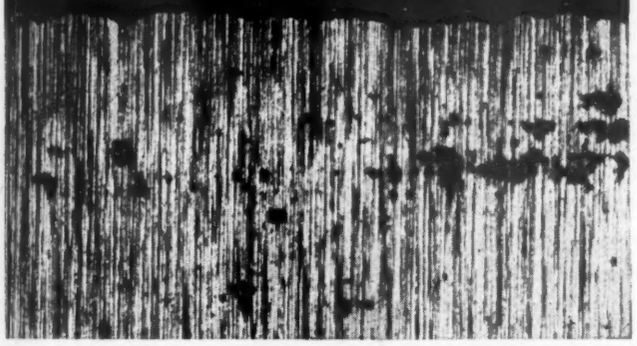
▸ **John Duncan, Jr.,** has been promoted to director of trade relations for Owens-Illinois Glass Company. Duncan, who has been representing the Kaylo Division in a similar capacity, will now handle special assignments for all units of the company and will report to Hugh C. Laughlin, vice president and general manager of the administrative division.

L. J. Troutz

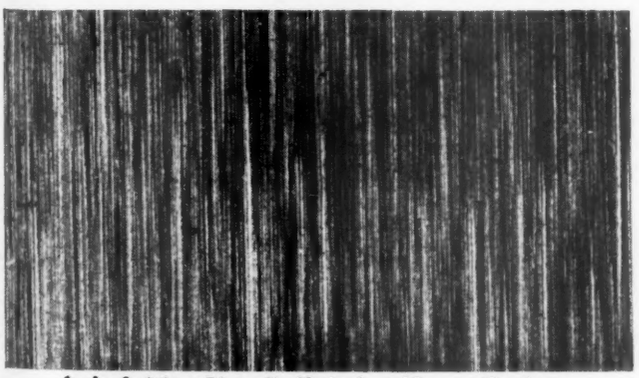
H. H. Hope

▸ **L. J. Troutz** is new Cummins Sales and Service, Inc., general service manager, and **H. H. Hope** has assumed new duties as division manager of diesel sales and service for Kansas and Oklahoma. Other promotions include: District managers of diesel sales and service: **R. J. Arroyo, L. W. Craft, Herbert Davis, W. N. Eason, G. E. Grimm, D. M. Peacock, C. E. Troutz,** and **A. C. Zugar.** New service managers are: **O. W. Boteler, W. R. Bowman, Lloyd Currell,** and **E. H. Smith.** Promoted as managers of diesel stores are: **E. C. Cain, J. T. Schedler,** and **R. E. Selleck.** New shop foremen are: **J. P. Hunter, W. P. Over,** and **G. C. Winfree.** New sales engineer in Oklahoma City is **J. G. Griffith.**

HERE'S *Positive Control* OF PITTING AND TUBERCULATION



Pitting with conventional treatment at 18 magnifications



Lack of pitting, Dianodic Method, at 18 magnifications

A complete report on the Dianodic Method of cooling water treatment. Ask for Technical Paper No. 123.

FOR years, industry has sought a method of chemical treatment that would provide *complete* protection against corrosion, pitting and scale in cooling water systems. Many present day methods for corrosion prevention do effect some decrease in metal loss, but unless excess treatment concentrations are used, localized attack in the form of pitting continues with ultimate metal failure.

Realizing the importance of this major problem, Betz Laboratories has developed the Dianodic Method, an advanced water treatment technique that assures *complete* protection. In this method, the combination of two anodic inhibitors under correct concentration and pH has proved time and again to control pitting and tuberculation, which conventional treatment is unable to control even at much higher concentrations. What's more, the Dianodic Method provides increased protection against general corrosion.

Here's what happened in one refinery which has a circulation rate of 40,000 gpm on its "cat" cracker system. The temperature drop through the tower is 15° F., with closed heat exchangers used for cooling purposes. Inspection of the system after ten months operation with conventional type treatment revealed freedom from scale and general corrosion, but *serious* pitting and tuberculation. Heads of the exchangers were deeply pitted and tubercles were built up to a height of 3 inches. The edges of the end around baffles were severely pitted and required "filling in" by welding. The Betz Dianodic Method was employed and after ten months the results were outstanding. Not only was scale and corrosion controlled, but pitting and tuberculation were eliminated entirely. The welded baffle ends were in perfect condition with the original welding marks clearly visible!

The development and successful field application of this new method of cooling water conditioning is just one example of the outstanding engineering service offered by BETZ. Why not let a Betz Engineer show how you can improve operating efficiency and cut costs in your plant? Write today. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal 1.

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Trade Personals

Rainey Elliott

L. G. Sutter

R. J. Woods, Jr.

J. T. Batchelor

Rainey Elliott has been elevated from director of sales to vice president and a director of Jones & Laughlin Supply Company. Elliott began in the oil field supply business in 1930, joining Jones and Laughlin at Electra, Texas, in 1935. In 1941, he was moved to Tulsa, Oklahoma, and was sales manager, general sales department, until appointed director of sales on January 1, 1952.

L. George Sutter succeeds Elliott as director of sales. He joined the company in 1926. Sutter was made chief engineer, machinery section, general products sales department in 1951.

Robert J. Woods, Jr., has been promoted from sales manager — J & L products to assistant director of sales. He joined Jones and Laughlin Steel in 1935. In 1944 he joined the Jones and Laughlin Supply as manager, J & L products sales.

James T. Batchelor, assistant sales manager — J & L Products, Tulsa, has been appointed sales manager — J & L products. Batchelor is a graduate of Cornell University, and before joining J & L in 1944 had been an employee of Jones and Laughlin Steel since 1926.

Oliver A. Bergmann, salesman — J & L products, has been appointed assistant sales manager — J & L products. Prior to joining the company in 1943 as a special representative in the tube sales department, Bergmann had been active in tube sales for other companies for several years.

William R. Clarke moves from assistant chief engineer, machinery section, general products sales department, to chief engineer. Clarke joined the company in 1936 as an engineer and clerk, machinery sales. He was promoted to assistant chief engineer, machinery section, general products, in 1951.

Robert E. Howe has been promoted from assistant to director of sales to sales coordinator, general sales department.

Howe began with Atlas Supply Company in 1914, later serving as sales manager until their purchase by Jones and Laughlin Supply in 1944, when he joined the company as assistant to sales manager.

Warren Carhart has been elected vice president of South Western Gear Works, of Houston, Texas. Carhart, who was formerly supervisor of application engineering at the company's Lynwood, California, plant will manage the Houston plant. A graduate mechanical engineer of the University of Syracuse, Carhart has been with the Pacific-Western group of companies for many years. Announcement of Carhart's election was made by T. J. Bannan, president.

H. S. Johnson has been promoted to director of merchandising, **L. M. Atwood** to assistant general sales manager, and **J. H. Alsen** to director of engineering applications of the Boston Woven Hose and Rubber Company.

Johnson has been with the company since 1936. He will direct the activities of the home office sales organization. Atwood in his new position will have responsibility for the company's general line field sales force. He joined the company in 1948. Alsen has held a number of positions since joining the company in 1920, and in his new post will be responsible for the application and sale of the company's products to original equipment manufacturers.

Howard Johnson has been named as district representative for Rector Well Equipment Company, Inc., with headquarters at Corpus Christi, to serve South Texas. Prior to his transfer to Corpus Christi, Johnson represented the company in the Alice, Texas, area. Before becoming associated with Rector Well Johnson was with a major oil company, for whom he was doing field service work in Louisiana.

Howard Johnson

Lawrence J. Straw has been named mobile sales manager of the Bendix Radio Division of Bendix Aviation Corporation. In his new capacity, he will head up a newly created national sales engineering organization, selling the Bendix line of two-way radio and communications systems. Straw joined Bendix in February, 1952.

W. H. "Bill" Griffin has been appointed manager of the perforating division, Johnston Testers, Inc. This division is introducing jet perforating service in combination with the Johnston formation tester, whose perforator is known by the trade name "Shoot-N-Test." Griffin was formerly division manager in the Gulf Coast territory for Welex Jet Services, Inc., and was recently promoted to assistant to the general sales manager. Griffin studied petroleum engineering and business administration at the University of Houston.

W. H. Griffin

C. B. Evans

S. E. Coombs

Charles B. Evans has been named manager of a new Schlumberger Well Surveying Corporation field office in Newhall, California. Evans joined Schlumberger in 1948 after receiving a degree in electrical engineering at the University of Southern California. Replacing Evans as manager of the Sacramento field office will be **Stanley E. Coombs.** Coombs received his degree at the University of Texas and joined Schlumberger in 1947.

Harry C. Oliver has been appointed sales manager of U. S. Tires, United States Rubber Company, tire division. Oliver, who has been assistant sales manager, will maintain offices in New York City. He succeeds **Lawler B. Reeves,** who has been appointed manager of the newly formed oil marketer sales division. Oliver joined U. S. Rubber in 1939. On January 1 of this year he was appointed assistant sales manager for U. S. Royal tires.

L. S. (Spider) Allen, manager of Armco Division of National Tank Company, returned late in September to Tulsa, Oklahoma, from a combination vacation and business trip to Canadian oil fields. He enjoyed three weeks of perfect weather and excellent fishing at Muskoka Lakes.

Ernest Lee Gardner, who has been in sales field engineering for Flexible Pipe Cleaning Company, Los Nietos, California, for the last six years, has been named district manager for the Mid-Continent area. His headquarters will be at 351 West Jefferson Boulevard, Dallas, Texas.

R. L. Bernhard, has been appointed manager of the newly-created centrifugal compressor department of the American Blower Corporation. Bernhard is a graduate of University of Alabama and brings to American Blower more than 18 years of experience in the centrifugal compressor field.

R. L. Bernhard

N. L. (Red) Warren, S. M. McNeely, and **N. L. Fincher** have been named service men to the Abilene, Texas, branch of Stewart and Stevenson Services. This brings the Abilene staff up to four men including C. A. (Chili) Weathered, manager.

F. H. Yeargers

W. W. Goode

F. H. Yeargers has been named to manage Schlumberger Well Surveying Corporation's Louisiana coast division at Lafayette, Louisiana. Yeargers succeeds **W. W. Goode** who has been transferred to Tulsa, Oklahoma, as assistant to the Mid-Continent area manager. Yeargers, a graduate of the University of Pittsburgh, joined Schlumberger in 1936. Goode joined Schlumberger in 1946. A graduate of the University of Alabama, he served in the New Iberia and Houma, Louisiana, districts.

Gardner P. Wilson has joined Consolidated Engineering Corporation as a senior development engineer. Wilson will be in charge of the mass spectrometer group of the engineering department, engaged in the design and development of mass spectrometers. From 1945 to 1952, Wilson was head of the test division of the United States Naval Ordnance Test Station at Pasadena, California.

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Chicago—Harry A. Jay, 122 So. Michigan Ave.
Denver—Earl H. Jones & Co., 1863 Wazee St.
Detroit—Thomas L. Osberger, 19451 Livernois Ave.
Erie, Pa.—R. J. Maggi, Box 713
Falmouth, Mass.—Wm. F. Bennett, 53 Minot St.
Houston—Henry H. Paris, Distributor, Inc., Box 932
Kansas City, Mo.—Wm. J. Hebenstreit, 3122 Coleman Rd.
Los Angeles—James A. Riordan Co., 1400 Santa Fe Ave.
Minneapolis—Lin J. Krause, 200 Lumber Exchange
Norbeth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Murray Eskin, Industrial Office Bldg.
New York—Henry Stein, 50 Cliff St.
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
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Seattle—Earl H. Jones & Co., 819 Thomas St.

FACTORY PHONE: WOODSDALE 3296

WHEELING MACHINE PRODUCTS COMPANY
ELM GROVE STATION WHEELING, W. VA.

Trade Personals

C. B. "Charlie" Foster has been appointed to the newly created position of sales manager—engines for Cummins Engine Company, Inc. In his new capacity, Foster will continue to be in charge of all Government contract work and, in addition, will take over the duties of the former position of manager—engine sales. Foster joined the Company in 1950.

C. B. Foster

Purdy Miller has been appointed manager of molded goods sales United States Rubber Company. Miller will make his headquarters in Passaic, New Jersey. He was formerly assistant manager of the Chicago, Illinois, branch and has had many years of experience in sales and branch management.

W. H. Kelly, Jr., assistant to the general construction superintendent of The Lummus Company, has been elected chairman of the Safety Committee of the National Constructors Association, to complete the unexpired term of **F. R. Griffin,** Koppers Company, the former chairman. The National Constructors Association is an organization composed of leading firms engaged on a national basis in the design and construction of chemical plants, petroleum refineries, and steel mills.

L. A. Elsener, manager of the Chicago Bridge and Iron Company's San Francisco office was elected a vice president of the company. Elsener was graduated with a BS degree in civil engineering from Purdue University in 1922. He has been associated with Chicago Bridge and Iron since 1922 immediately following his graduation.

Edward A. McCabe has been named manager of Gustin-Bacon Manufacturing Company's New York division. McCabe will be in charge of all glass fiber insulation, industrial and railroad division sales in New England, New York, New Jersey, Pennsylvania and Delaware. He has been with Gustin-Bacon since 1942. Prior to that time, he was special engineer in the office of the executive vice president of the New York Central System.

E. A. McCabe

John E. Lancaster has been appointed assistant chief engineer of the air conditioning and refrigeration engineering division, Worthington Corporation. He was graduated with a B.S. from Maryville College, and from New York University, joining Worthington in 1940.

William C. Osborne has been appointed manager of the research and development department. He was graduated from Rensselaer Polytechnic Institute and Princeton University.

Norman L. Meyerson has been appointed assistant manager of the research and development department. He received his BS degree from the University of Missouri, before he joined Worthington.

Frederick C. Gilman has been appointed research engineer. He was graduated from Stevens Institute of Technology and served Episcopal Church missions in China in various engineering and teaching capacities, joining Worthington in 1937.

T. A. Herman has been appointed assistant chief engineer of the reciprocating engineering division. He was graduated from Newark College of Engineering and New York University.

L .A. Dixon, Jr., has been named vice president of Rockwell Manufacturing Company's meter and valve division. Dixon will coordinate the sale and manufacture of gas, water, and oil meters, gas pressure regulators and Nordstrom valves. Dixon has a long relationship with the meter industry, having devoted his full time to it after graduating from the Pennsylvania State College.

L. A. Dixon, Jr.

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Trade Personals

Walter Lambert and Richard A. Matheis have been appointed to the Pittsburgh sales office by The Trane Company. Lambert received a degree in mechanical engineering from Virginia Polytechnic Institute. Matheis was formerly associated with the general sales department in the main office of The Trane Company at La Crosse. He is an industrial engineer graduate of Lehigh University.

Stan Mangham has been appointed to the Atlanta, Georgia, sales office. Mangham is a 1952 graduate of The Trane Student Training Program. He received his mechanical engineering degree from Georgia Tech.

William H. Steinkamp has been appointed vice president and general sales manager of Beckman Instruments, Inc. Steinkamp spent 22 years with the Brown Instruments Division of Minneapolis Honeywell Regulator Company where he served last as general sales manager, in Philadelphia.

W. H. Steinkamp

I. N. Towne has been named vice president of Brown and Root, Inc. Towne will operate out of Houston, and has just been recalled from the island of Guam where for the past six years he has been project manager of a large construction contract employing over 7500 men. Prior to his service with the joint venture Towne was with the Massman Construction Company of Kansas City.

W. R. Gottshall, who served since September 1951 with the Petroleum Administration for Defense, Washington, recently returned to his position with the Continental Supply Company, Dallas, Texas. Gottshall, manager of tubular sales, was on leave from Continental and served as Chief of the Metals and Minerals (control materials) branch of PAD. Becoming manager of Tubular Sales for Continental in August of 1949, Gottshall had been with the organization since 1936. He was formerly manager of tubular sales in Shreveport, Louisiana, for the Company.

W. R. Gottshall

Richard T. Bules has been appointed manager, V-Belt sales, industrial products sales department, for The B. F. Goodrich Company. He succeeds George J. Fischer who resigned recently. Bules has been with B. F. Goodrich for the past 12 years. He attended the University of Akron while working part time at BFG. Upon his graduation from Akron University in 1946 he joined the V-Belt sales department as a sales correspondent. He filled various capacities in sales with the company.

REPUBLIC NATIONAL BANK
OF DALLAS, TEXAS

Statement of Condition, September 5, 1952

RESOURCES

Cash and Due from Banks	$133,499,272.78
U. S. Government Securities	79,811,618.77
State, Municipal and Other Securities	2,939,092.16
Stock in Federal Reserve Bank	1,275,000.00
Loans and Discounts	226,205,602.19
Bills of Exchange and Commodity Loans	13,527,140.27
Real Estate — New Building and Equipment	6,376,179.42
Acceptances and Letters of Credit	4,613,679.93
Total	$468,247,585.52

LIABILITIES

Capital	$ 21,000,000.00	
Surplus	21,500,000.00	
Undivided Profits	5,322,189.78	47,822,189.78
Reserve for Monthly Dividend, Payable October 1, 1951		199,500.00
Reserve for Contingencies		3,306,883.42
Reserve for Taxes, Etc.		4,003,149.52
Acceptances and Letters of Credit		4,613,679.93
Deposits:		
Individual	288,128,786.15	
Banks	108,794,721.80	
Government	11,378,674.92	408,302,182.87
Total		$468,247,585.52

★ ★ ★

Assets of the Republic National Company, with capital stock of $3,000,000, are not included in above statement. The Company owns majority stock in the following banks located in Greater Dallas:

FAIR PARK NATIONAL BANK
GREENVILLE AVENUE STATE BANK
HIGHLAND PARK STATE BANK
LAKEWOOD STATE BANK
NATIONAL CITY BANK
OAK CLIFF BANK & TRUST CO.
OAK LAWN NATIONAL BANK

Resources of the Republic National Bank and the above Banks aggregate $588,277,997.00

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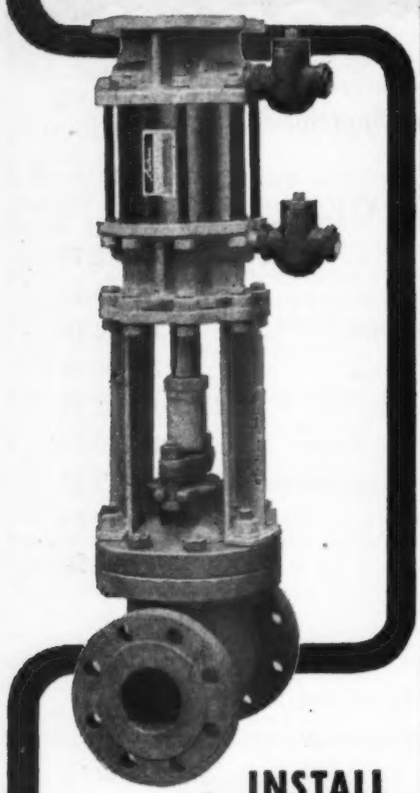
IF *Your* VALVES ARE DIFFICULT OR COSTLY TO OPERATE



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If you require automatic controls or power operation—or if your plant uses many valves in remote or inaccessible spots, you can save manpower and simplify your operations by installing Ledeen Valve Actuators. Adaptable to most any make, size and type of valve to operate against any line pressure, for any fluid medium, with any pressure. Positive, rugged, economical.

Write for Bulletin 512

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VALVE ACTUATORS • AIR HOISTS

Ledeen Mfg. Co.
1608 San Pedro
Los Angeles 15, Calif.

Trade Personals

▸ **H. H. Rakestraw** has been appointed by United Supply and Manufacturing Company of Tulsa to manage the firm's newest oil supply store in Ardmore, Oklahoma. This is United's 21st supply store. Rakestraw was formerly a sales representative in West Texas before going to his new post. Previously, he was store manager of the United supply store in Ringwood, Oklahoma.

H. H. Rakestraw

▸ **J. J. Farrell** has been appointed assistant treasurer of United States Steel Company. Farrell has been division treasurer of American Steel and Wire with offices in Cleveland, Ohio. A graduate of New York University, where he majored in finance and accounting, Farrell was first employed by U. S. Steel in 1922 as an office boy in the New York office of American Steel and Wire. **Herbert J. Watt** has been appointed assistant vice president — sales, Western area, and **F. Royal Gammon** as assistant vice president — sales, Eastern area, United States Steel. Gammon and Watt are widely known throughout the steel industry. In their new posts they will serve as representatives of the vice president — sales in their respective areas and will assist him in matters pertaining to selling. Gammon is located in New York City. Watt is stationed in Chicago.

▸ **C. R. Boll, Jr.**, has been appointed general sales manager, Cummins Engine Company, Inc. He will be responsible for engine, parts and contract sales, the company regional organization, advertising and sales development. Until his promotion, Boll was manager — engine sales, a position he had held since December, 1948. His career at Cummins began in 1941, following his graduation from Purdue University.

C. R. Boll, Jr.

▸ **Earl J. Mills** has been named manager of Diamond Alkali Company's Chicago branch sales office, succeeding the late Charles W. Klaus. John W. Kennady will be manager of the Southwest district sales office, which has its headquarters at Houston, Texas. Mills is a veteran member of Diamond's sales department.

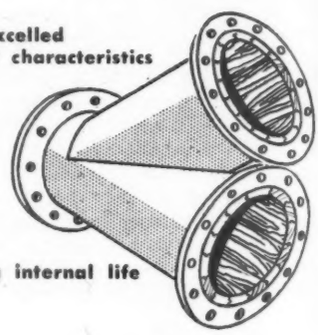
In August, 1949, when Diamond decided to expand and coordinate its fast growing sales and service activities in the Southwest, Mills was selected to be the first head of this consolidated and enlarged operation. Kennady comes to the Diamond sales organization from Kolker Chemical Works, Inc., a Diamond subsidiary. A native Pennsylvanian, Mills was graduated from Penn State College in 1932.

5 reasons WHY

mpc WOOD-LINED STEEL PIPE IS IMPORTANT TO THE PETROLEUM INDUSTRY

1 Non-corroding

2 Unexcelled flow characteristics



3 Long internal life

4 Unexcelled cushioning capacity against pulsations, vibrations and other mechanical influences

5 Low cost

Combines the strength of steel with the durability of wood. Recommended for salt water lines, desalting service, dilute caustic soda and polysulfide transport, acid wastes, cooling tower service and oil gathering lines. Operating service up to 250 p.s.i. and 180°F. Higher pressure ratings for special service requirements. All pipe flanged and available in 10′ and 20′ standard lengths or custom fabricated to specifications. Diameters 4″ thru 48″. Easy to cut and re-flange. All flanges have standard ASME bolt circle.

Wood-lined fittings in standard and special designs for all diameters. For catalog and additional information, write Dept. PE.

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Bay City • Michigan
Manufacturers of Wood-Stave, Saran Rubber-Lined, Stainless Steel and Monel Piping

BOOKS

Reviews of Petroleum Technology, *Vol. 12 (covering 1950). Published by the Institute of Petroleum, 26 Portland Place, London W.1., England, Price, $7, post free. Pages 513.*

This volume covers in general the year 1950, and practically all phases of the petroleum industry are dealt with, there being over 3300 references to articles which appeared in the literature during the period under review. Included in this volume are also a few reviews that cover the period 1949-50, these being general geology and development, engine testing, (both fuels and lubricants,) furnace fuel oil, lubricants, and engine and automotive equipment, while in the case of refinery plant and engineering the period is 1948-50. Other subjects include: Cracking and other processes, special products, oils from coal, shale, and other materials, corrosion, petroleum literature, geophysics, drilling, and production.

Oil and Gas Fields of the Texas Upper Gulf Coast, *by Frank J. Gardner. Published by Petroleum News Corporation, Box 331, Houston, Texas. Price, $25, subscribers; $35, non-subscribers. Pages, 484.*

The second reference volume of the series devoted to Railroad Commission districts in Texas takes in the 29 counties of District 3. Seventy-one geological structural maps and cross sections, 10 field maps, and 29 full county maps directly from the recent Commission hearings, as well as an area map of the entire district, showing all 427 oil and gas fields discussed in the text, with connecting pipe lines, are included in this volume. Each field in every county is described with information on: Site, means of discovery, discovery wells, elevation, productive acreage, deepest wells, number of wells on production, proration and spacing rule, allowable, average each well, market outlet, principal operator, typical formation sequence, production records, and other remarks.

Oil and Petroleum Yearbook, *1952, published by Walter E. Skinner, 20 Copthall Avenue, London, E.C.2. Price, $4, post free. Pages, 299.*

The 1952 edition, the forty-third year of issue, of this standard reference work, compiled by Walter E. Skinner, has just been published. Complete and up-to-date particulars are given concerning 800 companies operating in all parts of the world and covering all branches of the oil industry, together with a list of names and addresses of 512 managers and engineers and the companies with which they are connected. The book contains information on the principal British, American, Canadian, and foreign companies.

The particulars of each company comprise names of directors and other officials, description of business, where operating, crude oil production, refinery runs, details of capital, dividends, and financial results. The Buyers' Guide of Manufacturers of oilfield and refinery equipment comprises 737 headings.

Petroleum Tankage and Transmission, *by Hubert L. O'Brien. Published by Graver Tank and Manufacturing Company, Inc. East Chicago, Indiana. Pages, 170.*

This is an attempt to bring together practical information of value to the engineers who deal with problems of petroleum storage. Data derived from practical experience have been correlated with theoretical information already published, to represent a composite of theory and operating reports. A great deal of Graver's research reading, analysis, and conference discussion has been utilized in the compilation of this book. The information obtained is presented graphically, a bit on the conservative side to offset the unavoidable, though slight inaccuracy of this method. Every effort has been made to define clearly any assumptions. Chapters include an analysis of: Storage of petroleum and its derivatives; conservation equipment, a guide to the economic selection of tankage, fluid flow in practice; notes on selection of pumps, and useful data. Numerous photographs, tables, and charts are included for practical evaluation.

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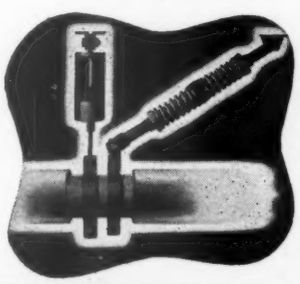

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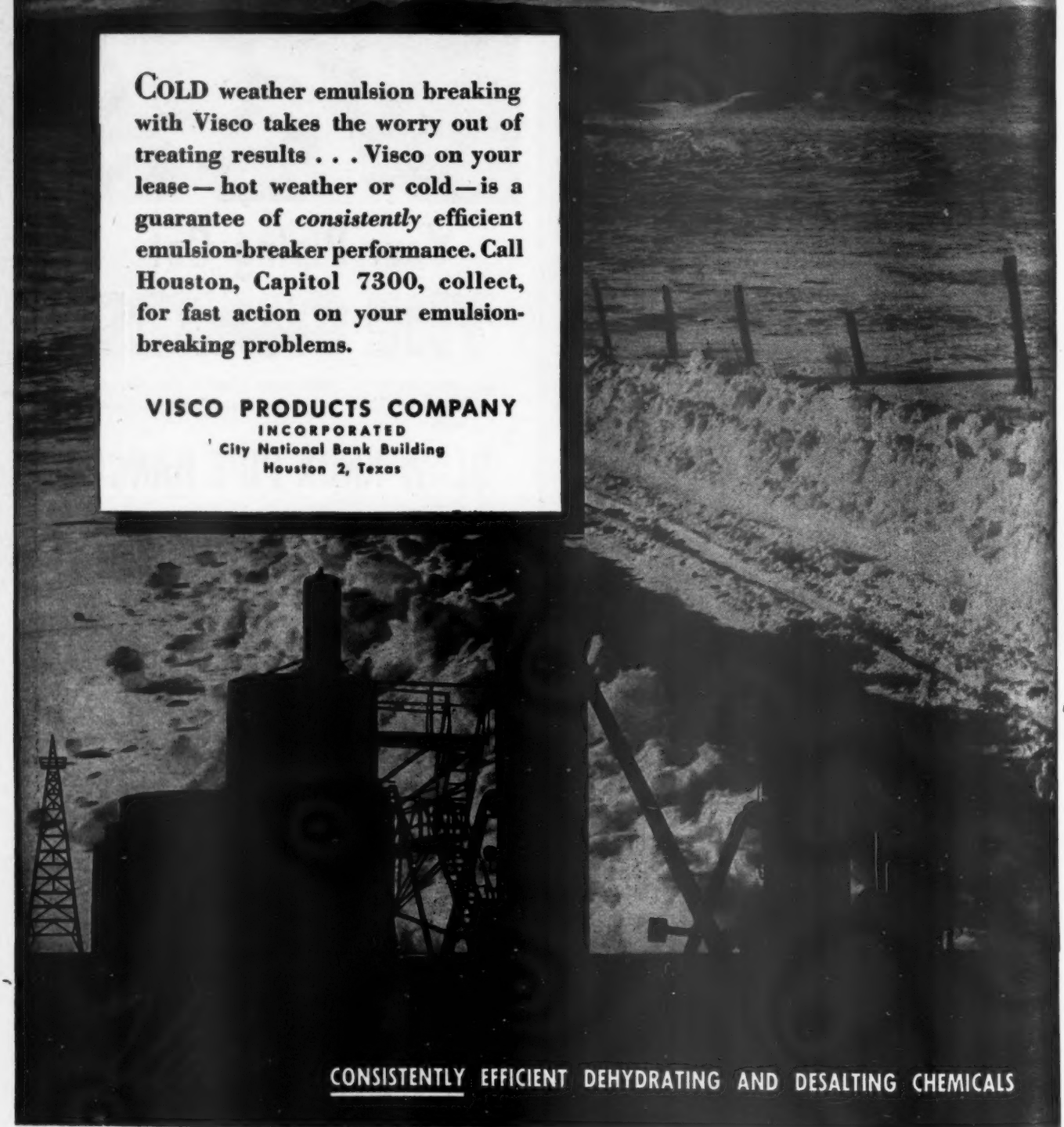

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